AN

INTRODUCTION

TO

ENTOMOLOGY

BY

JOHN HENRY COMSTOCK

PROFESSOR OF ENTOMOLOGY AND GENERAL INVERTEBRATE ZOÖLOGY
IN CORNELL UNIVERSITY

AND FORMERLY

UNITED STATES ENTOMOLOGIST

WITH MANY ORIGINAL ILLUSTRATIONS

DRAWN AND ENGRAVED BY

ANNA BOTSFORD COMSTOCK

ITHACA, N. Y.
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PREFACE TO PART I.

THIS work has been prepared to meet the demand for a text-book which shall enable students to acquire a thorough knowledge of the elementary principles of Entomology, and to classify insects by means of analytical keys similar to those used in Botany. By means of the keys the student can readily determine to what family any insect of which he has a specimen belongs. In many cases tables of genera are also given; and the more common or conspicuous species in each family have been described.

Although much pains has been taken to render easy the classification of specimens, an effort has been made to give the mere determination of the names of insects a very subordinate place. The groups of insects have been fully characterized, so that their relative affinities may be learned; and much space has been given to accounts of the habits and transformations of the forms described. As the needs of Agricultural students have been kept constantly in view, those species that are of economic importance have been described as fully as practicable, and particular attention has been given to descriptions of the methods of destroying those that are noxious, or of preventing their ravages.

The pronunciation of the technical terms has been indicated by marking the accented vowel, and at the same time indicating its length *when the term is pronounced as an English word.*

All the illustrations not credited to other sources are original, and have been drawn and engraved by Mrs. Comstock.

The specimens that have been studied in the preparation of this work are nearly all in the collections of the Entomological Depart-

ment of Cornell University. That these collections are in a sufficiently good condition for this purpose is due very largely to the generous assistance of many Entomologists. Specific acknowledgments will be made later.

As the completion of the work has been delayed by other duties, it has seemed best to issue this part at this time. Other chapters will be published as soon as practicable. In addition to the systematic part, the scope of which can be inferred from that given here, there are to be chapters on the Means of Destroying Insects or of Preventing their Ravages, the Collection and Preservation of Entomological Specimens, Entomological Supplies, a Classified List of Entomological Works, a Glossary, and an Introductory Chapter.

JOHN HENRY COMSTOCK.

ENTOMOLOGICAL LABORATORY, CORNELL UNIVERSITY,
September, 1888.

AN INTRODUCTION TO ENTOMOLOGY.

CHAPTER I.

THE CHARACTERS AND METAMORPHOSES OF INSECTS (HEXAPODA).

I. The Characters of the Hexapoda.

The term Insect is from two Latin words—*in*, in, and *seco*, to cut. It refers to the fact that in the animals indicated by it the body is divided by transverse incisions into a series of segments. As has been shown in the Introductory Chapter, this insected form of the body is characteristic of two of the larger divisions of the Animal Kingdom, the *Vermes*, or Worms and the *Arthropoda*. But the term Insect has become restricted to a portion of this great series of animals. There is, however, a lack of uniformity in the use of the term among zoological writers. By some it is applied to all Arthropoda that breathe by means of a system of air-tubes (*tracheæ*) extending throughout the body. This includes Centipedes, Millepedes, Spiders and allied forms, as well as the six-footed insects. Other writers include among Insects only those orders which are characterized by the possession of but six legs. It is in this restricted sense that I have used the term Insect. Whenever reference is made to all of the Arthropoda that breathe by means of tracheæ, they are designated as the *Tracheāta*.

Insects, in the restricted sense indicated above, constitute the class Hexapoda.* The insected or segmented form of the body is shown in Fig. 1, and in nearly all of the species figured in the following pages. The peculiar structure of the respiratory system, which is characteristic of these animals, and which allies them to other Tracheata, is described in the next chapter. In the Hexapoda

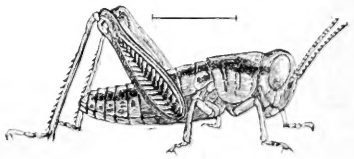


Fig. 1.—Nymph of the Red-legged Locust. (After Emerton.)

* Hexăpoda : *hex* (ἕξ), six; *pous* (πούς), a foot.

the typical adult is furnished with six legs; the segments of the body are grouped into three regions, head, thorax, and abdomen, Fig. 2; and the body is usually furnished with wings. Exceptions to each of these characteristics occur. The more important of these exceptions are discussed in the course of the following chapters.

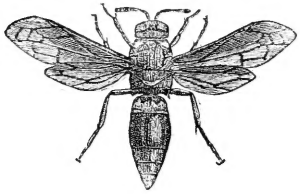


FIG. 2.—*Monobia.*

II. THE METAMORPHOSES OF INSECTS.

Among the marvellous facts revealed by the study of insects, none is more striking than the wonderful transformations which many of these creatures undergo. A large part of this book is devoted to indicating these changes. In this chapter I wish simply to make a few generalizations regarding the metamorphoses of insects, and to define a few terms which are used in describing these changes.

Complete Metamorphosis.— From the egg of a butterfly there emerges a worm-like creature, known as a caterpillar, which has upon superficial examination very little in common with its parents. This caterpillar eats and grows, and when fully grown changes to an oblong, apparently lifeless object, the chrysalis. After a time there bursts forth from this chrysalis a butterfly, like that which produced the egg. In a similar way, from the egg laid by a fly upon a piece of meat there hatches, not a fly, but a footless, worm-like maggot. This when fully grown changes to a quiescent object corresponding to the chrysalis of the butterfly. Later from this object there escapes a winged fly like that which laid the egg. Those insects, like the butterflies and flesh-flies, which when they emerge from the egg bear almost no resemblance in form to the adult insect are said to undergo a *complete metamorphosis*. In other words, the change of form undergone by the insect is a complete one.

Incomplete Metamorphosis.—There are, however, many insects which after leaving the egg do not undergo such a remarkable change of form as that indicated above. A young grasshopper just out from the egg can be easily recognized as a grasshopper. It is of course much smaller than the adult, and is not furnished with wings. Still the form of the body is essentially the same as that of an adult. After a time rudimentary wings appear; and these increase in size from time to time till the adult state is reached. During this development there is no point at which the insect passes

into a quiescent state corresponding to the chrysalis state of the butterfly. Those insects which, like the grasshoppers, when they emerge from the egg resemble in form the adult are said to undergo an *incomplete metamorphosis*. In other words, after leaving the egg they do not undergo a complete change of form.

Moulting, Exūviæ.—The body-wall of an insect is rendered more or less hard by the deposition within its cuticular layer of a horny substance known as chitine. The result of this hardening of the skin is to render it inelastic. Consequently as the body of an insect increases in size its skin becomes too small for it. When this occurs a second soft skin is formed beneath the outer hard one. Then the outer skin splits open, usually along the back, and the insect works itself out from it. The new skin being elastic accommodates itself to the increased size of the body. In a short time this new skin becomes hardened; and as the insect grows, it in turn is cast off. This shedding of the skin is termed *moulting* or *ĕcdysis*. The cast skins are sometimes referred to as the *exūviæ*. The number of moults varies greatly in the different groups of insects. In Fig. 3 is shown the cast skin of a dragon-fly clinging to a reed.

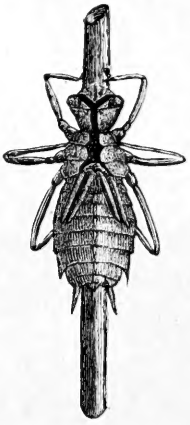


FIG. 3.—Exuviæ of a Dragon-fly.

The Egg.—The egg is the first of the four principal stages through which an insect passes in the course of its development. In a few instances the egg is retained within the body of the female until after it is hatched; in this case the insect is said to be *viviparous*. An apparent exception to the rule that all insects are produced from eggs is presented by certain generations of the Plant-lice (*Aphididæ*). This is discussed in the description of that family. The eggs of insects vary greatly in their external characters. While many of them are furnished with smooth oval shells, in others the shells are beautifully ribbed, or pitted (Fig. 4), or furnished with spines or other appendages. There exists also in one end of the egg of an insect one or more pores known as *mīcropyles;* through these the

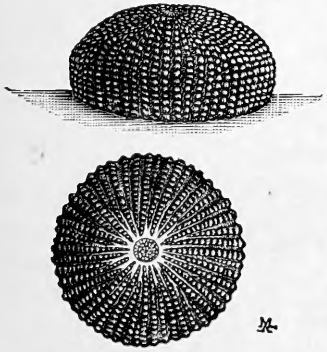


FIG. 4.—Egg of Cotton-worm, greatly enlarged. (From the Author's Report on Cotton Insects.)

spermatozoa pass into the egg, and thus fertilize it. Many of the interesting exhibitions of instinctive powers which I have described in the following pages are connected with the care of their eggs by insects.

The Lărva.—The larva is the second of the four principal stages in the life of an insect. It is the stage in which an insect emerges from the egg. Familiar examples of larvæ are caterpillars, maggots, grubs, etc. (Fig. 5). It is during the larval state that the growth of the insect is made; and consequently in this stage nearly all the moults are undergone. The moults subsequent to this period are simply those made when the insect changes from one stage to another.

FIG. 5.—Larva of *Diatrĭæa*. (From the Author's Report for 1879.)

Nearly all of the creatures commonly known as worms are not true worms, but are the larvæ of insects. Away from the sea-shore but few worms are known to other than zoologists; these are earth-worms, leeches, hair-worms, and the various species parasitic in the bodies of higher animals. The many worm-like animals found feeding upon the tissues of plants, as tomato-worms, apple worms, etc., are the larvæ of insects. Other larvæ of insects are predaceous or parasitic.

The Pūpa.—The pupa is the third of the four stages in the life of an insect. In this stage the insect is usually quiescent. But a few pupæ, as those of mosquitoes, are active. The change from the larva to the pupa state is made by moulting the skin of the fully grown larva. In the pupa the legs and wings of the adult are represented in a rudimentary state. In the pupæ of butterflies and moths these organs are closely soldered to the breast of the insect (Fig. 6), while in the pupæ of bees, wasps, and beetles they are free.

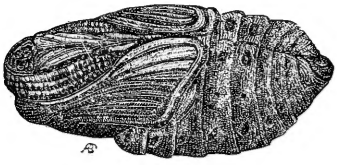


FIG. 6.—Pupa of *Platysamia*.

Chrÿsalis.—The term chrysalis is applied to the pupa of a butterfly. This name was suggested by the bright, metallic spots with which the pupæ of certain butterflies are marked. Two forms of this word are in use: chrysalis, *pl.* chrysalides; and chrysalid, *pl.* chrysalids.

The Cocoon.—Many larvæ, as those of moths, when fully grown, and before they change to pupæ, spin about the body a silken case,

within which the transformations are undergone. This case is termed a *cocoon*. Frequently these cocoons are made within a rolled leaf (Fig. 7), or on the surface of the ground, where they are covered with dry grass or other rubbish. Certain hairy caterpillars make their cocoons largely of their hair, which they fasten together by a thin film of silk.

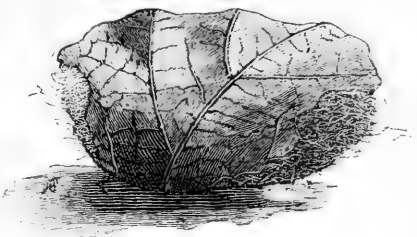


FIG. 7.—Cocoon of *Telia*.

Immature Forms of Insects with Incomplete Metamorphosis, The Nymph.—The terms larva and pupa are applicable only to the early

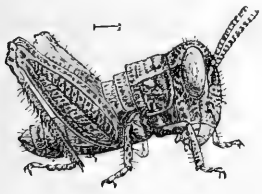


FIG. 8.—Nymph of *Melanoplus*, first stage. (After Emerton.)

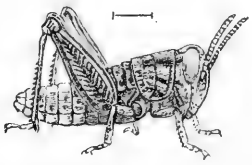


FIG. 9.—Nymph of *Melanoplus*, second stage. (After Emerton.)

stages of insects with a complete metamorphosis. In the case of those in which the transformation is an incomplete one, the changes through which the immature insect passes after leaving the egg are

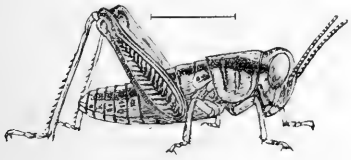


FIG. 10.—Nymph of *Melanoplus*, third stage. (After Emerton.)

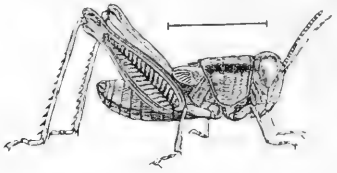


FIG. 11.—Nymph of *Melanoplus*, fourth stage. (After Emerton.)

so gradual that one cannot indicate any point at which the insect ceases to be a larva and becomes a pupa. Recent writers have used, therefore, the term *nymph* (a term formerly used as a synonym of pupa) to designate the immature forms of insects with an incomplete metamorphosis. This term is applied to all the stages between the egg and the fully winged or adult state.

A nymph when it leaves the egg has no indications of wings. After undergoing a greater or less number of moults, differing in different species, small prolongations appear projecting from the

dorsal aspect of the meso- and metathorax. These become larger and larger with each successive moult, assuming the form of pad-

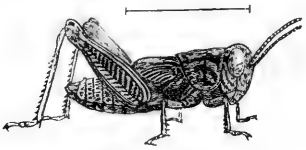


FIG. 12.—Nymph of *Melanoplus*, fifth stage. (After Emerton.)

FIG. 13.—*Melanoplus*, adult.

like wing-cases. But these wing-cases never approximate in length the perfect wings of insects in which these organs become fully developed. There is, therefore, usually a very marked change between the last nymph stage and the mature insect. (See Figs. 12 and 13.)

With the nymphs of certain families, dragon-flies, crickets, grasshoppers, and locusts, the wing-cases are inverted; *i.e.*, the aspect corresponding to the upper side of the wing is next to the body, and the first pair of wing-cases extend back beneath the second pair. This characteristic is useful in distinguishing the adult forms from the nymphs of those species in which the wings never become fully developed.

CHAPTER II.

THE ANATOMY OF INSECTS.

THE subject of insect anatomy is separated into two divisions: one, treating of the structure of the body-wall or skeleton; the other, of the internal organs. The former is termed *external anatomy;* the latter, *internal anatomy.*

THE EXTERNAL ANATOMY OF INSECTS.*

The relative positions of the more important parts of the body of insects can be easily comprehended by recalling what has been said, in the Introductory Chapter, regarding the type of structure presented by the Arthropoda. In this branch of the Animal Kingdom, which includes insects, the body is an elongated cylinder composed of many rings (Fig. 14). A cross-section of the body shows it to be

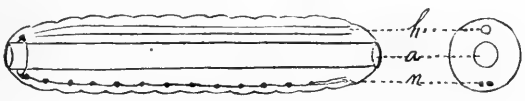


FIG. 14.—Diagram of structure of Arthropoda.

a tube within which are the various viscera,—muscles, alimentary canal, heart, nervous system, reproductive organs, etc. The tubular body-wall, being hardened and furnishing support to the softer organs, is the skeleton. This hardening of the body-wall is due to the deposition in it of some hard substance. In insects the substance thus deposited is horny, and is termed *chītine.*

Between certain rings or segments of the body the body-wall remains soft and flexible. In this way provision is made for the various motions of the body. The ring-like nature of the segments is best seen in larvæ, and in the caudal part of adult insects. In the cephalic part of adult insects it is less obvious.

When a single segment of the body is examined, the hardened portion is not found to be a continuous ring, but is seen to be made up of several portions more or less movable upon each other. Such a hardened portion of the body-wall is termed a *sclērite.*

* See Tabular Review at the end of this part of this chapter for an explanation of the lettering of the illustrations.

The sclerites constitute the greater part of the body-wall, the soft membranous portions separating them being in most cases narrow. Usually these narrow portions are mere lines; they are then called *sūtures*.

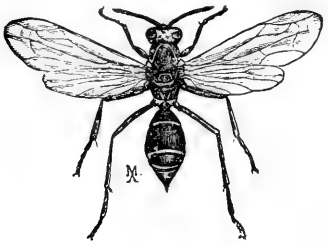


Fig. 15.—*Polistes bellicosa.*

Frequently the sutures become entirely effaced. We are therefore often unable to distinguish certain sclerites in one species of insect which we know to exist in another. In such cases the effaced sutures are said to be *obsolete*.

The segments of the body in a fully developed insect are grouped into three regions: *head*, *thorax*, and *abdomen* (Fig. 15). In the larval state this grouping of the segments is not well shown.

The Head.

The head is the first of the three regions of the body. It is supposed to be formed of several body-segments grown together; but entomologists differ in their views as to the number of segments that have entered into its composition.

It does not fall within the scope of this work to enter into this discussion. The main point, however, can be stated here. A careful study of the various forms of Arthropods shows that the typical body-segment possesses a pair of legs, and only one pair. It is known that certain mouth parts (mandibles, maxillæ, and labium) are modified legs. (This fact is easily seen in many Crustacea.) The antennæ and the eyes may also be modified legs.* It follows that if we find represented in the appendages of the head the appendages of several segments, the head itself must consist of several segments coalesced.

The principal portion of the chitinized parts of the head are firmly joined together so as to constitute a box which contains the brain of the insect and certain other important organs. To this are articulated a number of jointed appendages. The parts of the head may be classed, therefore, under two divisions: first, the fixed parts; second, the movable parts.

The Fixed Parts of the Head.

In addition to the external portions of the organs of vision (the compound eyes, and the simple eyes), the fixed parts of the head consist of four sclerites. Three of these sclerites (occiput, epicra-

* The belief that the eyes are modified legs is based on the fact that in certain Crustacea the eyes are situated on stalks which are jointed appendages of the head.

nium, and clypeus) pertain to the dorsal surface; and the fourth (gula) to the ventral surface.

Frequently the sutures between some of these sclerites are obsolete; but by studying a series of insects each of these parts can be distinguished.

The Compound Eyes.—In many insects the most striking in appearance of the fixed parts of the head are the eyes (3).* These are situated one on each lateral aspect of the head. They are usually nearly hemispherical and of considerable size. When examined with a microscope, they present the honey-comb-like appearance shown in Fig. 16. Each of the hexagonal divisions of the eye is a cornea of a distinct eye. These large eyes are therefore compound. Each of the small eyes of which they are composed is termed an *ocĕllus*. Compound eyes are not found in larvæ.

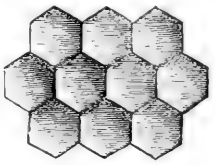


FIG. 16.—Part of compound eye, greatly enlarged.

The Simple Eyes.—In addition to the compound eyes, many insects possess simple eyes (4). These are situated in adult insects on the dorsal aspect of the head between the compound eyes, and in larvæ on the sides of the head. They vary in number in the adult from one to four. The most common number is three; see Fig. 15. Each simple eye resembles an ocellus of a compound eye. The simple eyes are usually termed *ocĕlli;* sometimes, *stĕmmata.*

When the term ocelli is used in descriptive works, if there is nothing in the context to indicate the contrary, it is almost invariably applied to the simple eyes, and not to the elements of the compound eyes. In the same way the term eye usually refers to the compound eyes, unless otherwise indicated by the context.

The Epicrānium.—The epicranium (2) is usually the largest of the three sclerites which pertain to the dorsal aspect of the head. It is that sclerite in which the simple eyes are situated, and which surrounds the compound eyes. It occupies an intermediate position in the dorsal aspect of the head, being bounded caudad† by the occiput, and cephalad by the clypeus.

From the fact that the epicranium occupies so large a part of the head, it frequently becomes necessary to speak of particular regions of it in making detailed descriptions of insects. Consequently names have been given to certain parts; although those parts are very rarely distinct. These names are *front, vĕrtex,* and *gĕnæ.* It is difficult to define definitely the regions of the epicranium to which these terms have been applied. Roughly speaking, the

* See Tabular Review at end of discussion of External Anatomy.

† For definitions of the terms denoting position and direction of parts, see Glossary.

front (2*a*) is the cephalic portion of the epicranium (Fig. 17). It is bounded cephalad by the clypeus, and laterad by the eyes and genæ. The *vertex* (2*b*) is the remaining part of the dorsal portion of the epicranium; it extends from between the eyes to the occiput. By many writers the term vertex is used in a vague manner to indicate the summit of the head. The *genæ* (2*c*) or cheeks are the lateral portions of the epicranium, those parts which are usually ventrad of the eyes and caudad of the mandibles. In many insects a distinct suture extends cephalad from each compound eye, separating the front from the genæ.

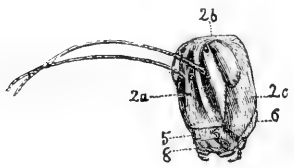


FIG. 17.—Head of locust.

The Occiput.—The occiput (1) is that part of the dorsal wall of the head which is articulated with the cephalic margin of the thorax (Fig. 18). In many insects it is a distinct sclerite; in others it is not distinguishable from the epicranium.

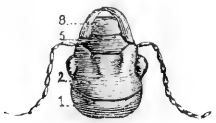


FIG. 18.—Dorsal aspect of head of *Harpalus*.

FIG. 19.—Ventral aspect of head of *Harpalus*.

The Clypeus.—The clypeus (5) is the cephalic part of the dorsal portion of the fixed parts of the head. It is bounded caudad by the epicranium, and gives attachment cephalad to one of the movable parts of the head, the labrum or upper lip. The clypeus is typically composed of two sclerites. When these are distinct they are designated as the *ante-clypeus* and *post-clypeus* respectively.

The Gula.—The gula (6) is the only one of the fixed parts of the head that is confined to the ventral aspect (Fig. 19). It is bounded laterad by the lateral parts of the epicranium and occiput; and extends caudad to the caudal border of the head. Cephalad it gives attachment to one of the movable parts of the head, the labium or lower lip.

The Movable Parts of the Head.

Under this category are classed a pair of jointed appendages termed the *antennæ*, and the organs known collectively as the *mouth-parts*.

The Antennæ.

The *antennæ* (7) are a pair of jointed appendages, inserted in the head in front of the eyes or between them. They vary in form. In some insects they are thread-like, consisting of a series of similar segments; in others certain segments are greatly modified in form. In the beetles of the genus *Collops* the antennæ bear a curious articulated appendage arising from near the base of the third segment.*

* Horn, Trans. Am. Ent. Soc., III. p. 79, with figure.

In descriptive works names have been given to particular parts of the antennæ, as follows (Fig. 20):

The Scāpe.—The first or proximal segment of an antenna is called the scape (*a*). The proximal end of this segment is often subglobose, appearing like a distinct segment; in such cases it is called the bulb.

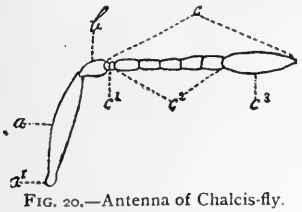


FIG. 20.—Antenna of Chalcis-fly.

The Pĕdicel.—The pedicel (*b*) is the second segment of an antenna. In some insects it differs greatly in form from the other segments.

The Clăvola.—The term clavola (*c*) is applied to that part of the antenna distad of the pedicel; in other words, to all of the antenna except the first and second segments. In some insects certain parts of the clavola are specialized and have received particular names. These are the ring-joints, the funicle, and the club.

The Ring-joints.—In certain insects (*e.g.*, Chalcididæ) the proximal segment or segments of the clavola are much shorter than the succeeding segments; in such cases they have received the name of ring-joints (c^1).

The Club.—In many insects the distal segments of the antennæ are more or less enlarged. In such cases they are termed the club (c^3).

The Fūnicle.—The funicle (c^2) is that part of the clavola between the club and the ring-joints; or, when the latter are not specialized, between the club and the pedicel.

The various forms of antennæ are designated by special terms. The more common of these forms are represented in Fig. 21. They are as follows:

1. *Setāceous* or bristle-like, in which the segments are successively smaller and smaller, the whole organ tapering to a point.

2. *Fĭliform* or thread-like, in which the segments are of nearly uniform thickness.

3. *Monĭliform* or necklace-form, in which the segments are more or less globose, suggesting a string of beads.

4. *Sĕrrate* or saw-like, in which the segments are triangular and project like the teeth of a saw.

5. *Pĕctinate* or comb-like, in which the segments have long processes on one side, like the teeth of a comb.

6. *Clāvate* or club-shaped, in which the segments become gradually broader, so that the whole organ assumes the form of a club.

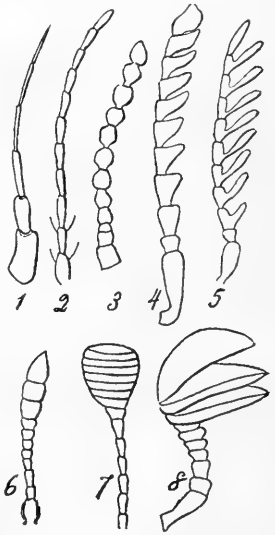


FIG. 21.—Various forms of antennæ.

7. *Căpitate* or with a head, in which the terminal segment or segments form a large knob.

8. *Lămellate*, in which the segments that compose the knob are extended on one side into broad plates.

The Mouth-parts.

The mouth-parts (Fig. 22) consist typically of an upper lip, *labrum* (8), an under lip, *labium* (12), and two pairs of jaws acting horizontally between them. The upper pair of jaws are called the *mandibles* (10); the lower pair, the *maxillæ* (11). The maxillæ and labium are each furnished with a pair of feelers, called respectively the *maxillary palpi* (11*d*), and the *labial palpi* (12*d*). There may be also within the mouth one or two tongue-like organs, the *epipharynx* (9) and *hypopharynx* (13).

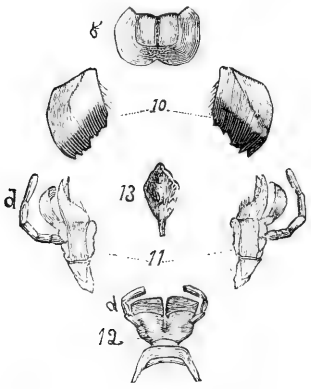


FIG. 22.—Mouth-parts of the Red-legged Locust.

No set of organs in the body of an insect vary in form to a greater degree than do the mouth-parts. Thus with some the mouth is formed for biting, while with others it is formed for sucking. Among the biting insects some are predaceous, and have jaws fitted for seizing and tearing their prey; others feed upon vegetable matter, and have jaws for chewing this kind of food. Among the sucking insects the butterfly merely sips the nectar from flowers, while the mosquito needs a powerful instrument for piercing its victim. In this chapter the typical form of the mouth-parts as illustrated by the biting insects is described. The various modifications of it presented by the sucking insects are described later, in the discussions of the characters of those insects.*

The Lăbrum.—The labrum or upper lip (8) is an appendage of the cephalic margin of the dorsal part of the head. It is usually a narrow transverse sclerite. In some insects it is large and projecting, and often notched; in others it is concealed beneath a largely developed clypeus.

The Măndibles.—The mandibles (10) are the dorsal pair of jaws. They vary much in form, but are usually three-sided, with their lateral † surface more or

* The more important papers on the nomenclature of the parts of the mouth in biting insects are the following:

KIRBY AND SPENCE. Introduction to Entomology, vol. III. (1818.)

MACLEAY, W. S. Horæ entomologicæ (2 vols., 1819, 1821). This work I have not seen.

STRAUS-DURCKHEIM, H. E. Considérations générale sur l'anatomie des animaux articulés. (1828.)

NEWMAN, EDWARD. A paper on the nomenclature of the parts of the head of insects. (1834.)

NEWPORT, G. The article "Insecta," Todd's Cycl. of Anat. and Physiol. (1839.)

BRULLE, A. Recherches sur les transformations des appendices dans les Articules. Annales des Sciences Naturelles, t. II. (1844.)

† I have not attempted to determine the normal position of the mouth-parts, but have described each with its distal end directed cephalad. This seems to me the way least likely to lead to confusion.

less convex, and their mesal surface concave. Usually each mandible consists of a single segment; but in some insects these organs are much more complicated.

In several genera of Rove-beetles (*Staphylinidæ*) each mandible is furnished with an appendage (Fig. 23). This was named the *prosthēca* by Kirby and Spence.

FIG. 23.—Mandible of *Staphylinus*.

Fig. 24.—Mandible of *Euphoria inda*.

In many beetles of the family Scarabæidæ each mandible consists of several more or less distinct sclerites. This is wel. shown in the mandible of *Euphoria inda* (Fig. 24). These compound mandibles have not yet been studied with sufficient care to enable us to definitely name the parts.

The Maxillæ.—The maxillæ (11) are the more ventral of the two pairs of jaws. They are much more complicated than the mandibles, each maxilla consisting, when all of the parts are present, of five primary parts and three appendages. The primary parts are the *cardo* or hinge, the *stipes* or footstalk, the *palpifer* or palpus-bearer, the *subgalea* or helmet-bearer, and the *lacinia* or blade. The appendages are the *maxillary palpus* or feeler, the *galea* or superior lobe, and the *digitus* or finger. The maxilla may also bear claw-like or tooth-like projections, spines, bristles, and hairs.

In the following description of the parts of the maxillæ, only very general statements can be made. Not only is there an infinite variation in the form of these parts, but the same part may have a very different outline on the dorsal aspect of the maxilla from what it has on the ventral. Compare Fig. 25 and Fig. 26, which represent the two aspects of the maxilla of *Hydrophilus*. Excepting Fig. 26, the figures of maxillæ represent the ventral aspect of this organ.

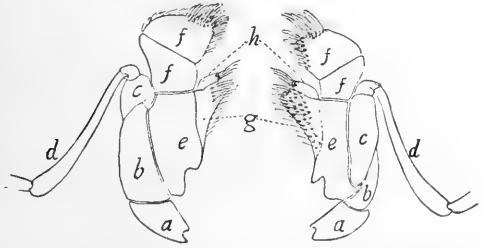


FIG. 25.—Ventral aspect of maxilla of *Hydrophilus*.

FIG. 26.—Dorsal aspect of maxilla of *Hydrophilus*.

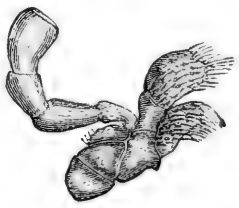


FIG. 27.—Maxilla of *Eleodes*.

The *Cărdo* or hinge (*a*) is the first or proximal part of the maxilla. It is usually more or less triangular in outline, and is the part upon which nearly all of the motions of this organ depend. In many cases, however, it is not the

only part directly joined to the body; for frequently muscles extend direct to the subgalea, without passing through the cardo.

The *Stipes* or footstalk (*b*) is the part next in order proceeding distad. It is usually triangular, and articulates with the cardo by its base, with the palpifer by its lateral margin, and with the subgalea by its mesal side. In the Orthoptera, Pseudoneuroptera, and Neuroptera, the stipes is united with the subgalea, and the two form the larger portion of the body of the maxilla (Fig. 22). The stipes has no appendages; but the palpifer on the one side, and the subgalea on the other, may become united to the stipes without any trace of suture remaining, and their appendages will then appear to be borne by the stipes. Thus in Fig. 22 it appears to be the stipes that bears the galea, and that receives muscles from the body.

The *Pălpifer* or palpus-bearer (*c*) is situated upon the lateral (outer) side of the stipes; it does not, however, extend to the base of this organ, and frequently projects distad beyond it. It is often much more developed on the dorsal side of the maxilla than on the ventral (Figs. 25 and 26). It can be readily distinguished when it is distinct by the insertion upon it of the appendage which gives to it its name.

The *Măxillary Pălpus* or feeler (*d*) is the most conspicuous of the appendages of the maxilla. It is an organ composed of from one to six freely movable segments, and is articulated to the palpifer on the latero-distal angle of the body of the maxilla.

The *Subgălea* or helmet-bearer (*e*) when developed as a distinct sclerite is most easily distinguished as the one that bears the galea. It bounds the stipes more or less completely on its mesal (inner) side, and is often directly connected with the body by muscles. In many Coleoptera it is closely united to the lacinia; this gives the lacinia the appearance of bearing the galea, and of being connected with the body (Fig. 28). In the Orthoptera, the Pseudoneuroptera, and the Neuroptera, the subgalea is united to the stipes; consequently in these orders the stipes appears to bear the galea, and to be joined directly to the body if any part besides the cardo is so connected.

The *Gălea* or helmet (*f*) is the second in prominence of the appendages of the maxilla. It consists of one or two segments, and is joined to the maxilla mesad of the palpus. The galea varies greatly in form: it is often more or less flattened, with the distal segment concave, and overlapping the lacinia like a hood. It was this form that suggested the name galea or helmet. In other cases the galea resembles a palpus in form (Fig. 28). The galea is also known as the *outer lobe*, the *upper lobe*, or the *superior lobe*.

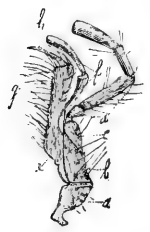


Fig. 28.—Maxilla of *Cicindela*.

The *Lacĭnia* or blade (*g*) is borne on the mesal (inner) margin of the subgalea. It is the cutting or chewing part of the maxilla, and is often furnished with teeth and spines. The lacinia is also known as the *inner lobe*, or the *inferior lobe*.

The *Dĭgitus* or finger (*h*) is a small appendage sometimes borne by the lacinia at its distal end. In the Cicindelidæ it is in the form of an articulated claw (Fig. 28); but in certain other beetles it is more obviously one of the segments of the maxilla (Figs. 25 and 26). This part is sometimes termed the *unguis*, a

name applied by Kirby and Spence to it and to the other claw-like projections of the maxilla. The French entomologists distinguish it as *le premaxillaire*. Neither of these names is desirable; the former is not restricted to this part of the maxilla, but is often applied to the terminal portion of the lacinia; the latter name is objectionable both in form and signification; it is hardly appropriate to apply the prefix *præ* to the most distal part of an appendage. I propose, therefore, the name *digitus* for this sclerite.

The Lăbium or Second Maxillæ.—The labium or under lip (12) is attached to the cephalic border of the gula, and is the most ventral of the mouth-parts. It appears to be a single organ, although sometimes cleft at its distal extremity; it is, however, composed of a pair of appendages grown together on the middle line of the body. In the Crustacea the parts corresponding to the labium of insects consist of two distinct organs, very closely resembling the maxillæ. In this case they are termed the second maxillæ, a name which is sometimes applied to the labium of insects. Hence in defining the Hexapoda it is stated that they have two pairs of maxillæ.

In naming the parts of the labium, entomologists have usually taken some form of it in which the two parts are completely grown together, that is, one which is not cleft on the middle line (Fig. 29). I will first describe such a labium, and later one in which the division into two parts is carried as far as we find it in insects.

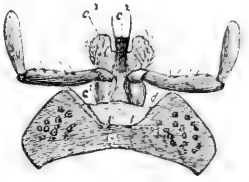


FIG. 29.—Labium of *Harpalus*.

The labium is usually described as consisting of three principal parts and a pair of appendages. The principal parts are the *submentum*, the *mentum*, and the *ligula*; the appendages are the *labial palpi*.

The basal part of the labium consists of two transverse sclerites; the proximal one, which is attached to the cephalic border of the gula, is the *submentum* (*a*). This is often the most prominent part of the body of the labium.

The *Mĕntum* (*b*) is the more distal of the two primary parts of the labium. It is articulated to the cephalic border of the submentum, and is often so slightly developed that it is concealed by the submentum.*

The *Lĭgula* (*c*) includes the remaining parts of the labium except the labial palpi. It is a compound organ; but in the higher insects the sutures between the different sclerites of which it is composed are usually obsolete. Three parts, however, are commonly distinguished (Fig. 29), a central part, often greatly prolonged, the *glŏssa* (c^2), and two parts, usually small membranous projections, one on each side of the base of the glossa, the *paraglŏssæ* (c^3).

* Unfortunately the term mentum is applied by some entomologists to the submentum, and the true mentum entirely overlooked or distinguished by a different name. This is the case in one of the most important works in the literature of American entomology, "The Classification of the Coleoptera of North America," by Le Conte and Horn. The student in the use of this indispensable work must bear this change of names in mind. These authors have termed the true mentum the *hypoglottis*, and state that in the Carabidæ the homologous portion is often called the "basal membrane of the ligula" (*l. c.* p. xviii).

Sometimes, however, the paraglossæ are large, exceeding the glossa in size From the base of the ligula arise a pair of appendages, the *lăbial pălpi* (*d*). Each labial palpus consists of from one to four freely movable segments.

In the form of the labium just described, the correspondence of its parts to the parts of the maxillæ is not easily seen ; but this is much more evident in the labium of some of the lower insects, as for example a cockroach (Fig. 30).

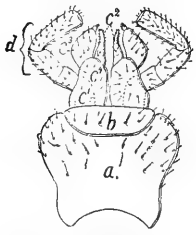


FIG. 30.—Labium of Cockroach.

Here the organ is very deeply cleft ; only the submentum and mentum remain united on the median line ; while the ligula consists of two distinct maxilla-like parts. It is easy in this case to trace the correspondence referred to above. Each lateral half of the submentum corresponds to the cardo of a maxilla ; each half of the mentum, to the stipes ; while the remaining parts of a maxilla are represented by each half of the ligula, as follows : near the base of the ligula there is a part (c^1) which bears the labial palpus ; this appears in the figure like a basal segment of the palpus ; but in many insects it is easily seen that it is undoubtedly one of the primary parts of the organ ; it has been named the *pălpiger*, and is the homologue of the palpifer of a maxilla. The trunk of each half of the ligula is formed by a large sclerite (c^4) to which I believe attention has not been called heretofore. This evidently corresponds to the subgalea. At the distal extremity of this subgalea of the labium there are two appendages. The lateral one of these (c^3) is the *paraglossa*, and obviously corresponds to the galea. The mesal one (c^2) corresponds to the lacinia or inner lobe. This part is probably wanting in those insects in which the glossa consists of an undivided part ; and in this case the glossa probably represents the united and more or less elongated subgaleæ.

The Epiphărynx and the Hypophărynx.—In addition to the mouth-parts described above, either the labrum or the labium may bear on its ental surface, within the cavity of the mouth, a more or less tongue-like organ. If borne by the labrum, it is termed the *epipharynx* (9) ; if by the labium, the *hypopharynx* (13). (See Fig. 22.) The epipharynx and the hypopharynx are rarely both developed in the same insect, except in some Hymenoptera. The form and position of the hypopharynx are analogous to those of the tongue of higher animals. On this account it has been named the *lĭngua* or tongue. But as both of these terms have been applied to the glossa, it is best to designate this part as the hypopharynx, and to avoid the use of the terms lingua and tongue, as liable to be ambiguous.

The Thorax.

The thorax is the second or intermediate region of the body. It is readily distinguished by its appendages, which are three pairs of legs and one or two pairs of wings. This region consists of three segments. The cephalic or first segment is named the *prothōrax* (14) ; the second, the *mesothōrax* (15) ; and the third, the *metathōrax* (16). Each segment bears a pair of legs ; and in winged insects the wings are borne by the second and third segments.

The Fixed Parts of the Thorax.*

Each segment of the thorax is composed of several sclerites. The shape and relative position of these sclerites afford characters which are much used in classification. Fig. 31 is a diagrammatic representation of what is considered the typical arrangement of these parts in each of the thoracic segments. Each segment of the thorax is a ring, which is divided into four parts: a dorsal, a ventral, and two lateral. The dorsal part is named the *nōtum* or *tĕrgum*; each lateral part the *pleūrum*; and the ventral part the *stĕrnum*.

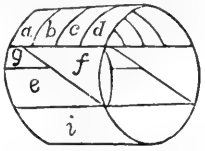


FIG. 31.—Diagram of the fixed parts of a thoracic segment.

When the notum or sternum of a particular thoracic segment is to be indicated, it is done by the use of one of the prefixes *pro*, *meso*, or *meta*. In this way are formed the terms *pronōtum*, *mesonōtum*, *metanōtum*, *prostĕrnum*, *mesostĕrnum* and *metastĕrnum*; which are applied to the nota and sterna of the prothorax, mesothorax and metathorax respectively.

By some writers the entire dorsal part of an insect is termed the *tĕrgum*; the lateral part, the *pleūrum*; and the ventral part, the *stĕrnum*. These writers apply the terms *tĕrgite*, *pleūrite*, and *stĕrnite* respectively to the dorsal, lateral and ventral regions of each segment.

The tergum of each thoracic segment is composed typically of four sclerites. These are arranged in a linear series. They are named, beginning with the first or most cephalic, *præscūtum* (*a*), *scutūm* (*b*), *scutĕllum* (*c*), and *postscutĕllum* (*d*). (Fig. 32.) In the prothorax the sutures between these four scle-

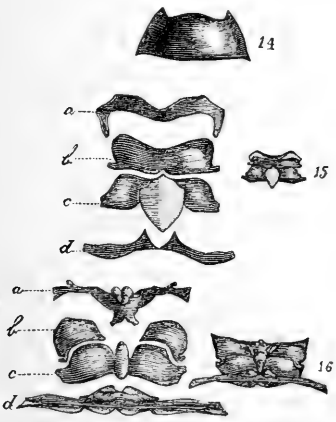


FIG. 32.—Dorsal aspect of the thorax of a beetle, *Dytiscus*, dissected. (After Audouin.)

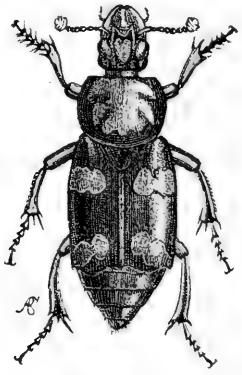


FIG. 33.—*Necrophorus*, to show scutellum.

* The more important works on the nomenclature of the parts of the thorax are the following:

Audouin, J. V. Recherches anatomiques sur le thorax des animaux articulés et celui des insectes hexapodes en particulier. Annales des Sciences Naturelles, T. I. (1824).

The works of *Kirby and Spence*, *MacLeay*, *Straus-Durckheim*, *Newman*, and *Newport* cited on p. 12. The description of the anatomy of the thorax by MacLeay was republished in the Ann. des Sci. Nat. t. 25 (1832).

rites are in many cases obsolete, the pronotum appearing to be composed of a single sclerite. In beetles and bugs the scutellum of the mesothorax is usually quite conspicuous, appearing as a more or less nearly triangular piece between the first pair of wings at their base (Fig. 33). Most entomological writers refer to this sclerite as *the* scutellum. Of the four sclerites which compose the tergal portion of each thoracic segment, the scutum is usually the largest; the scutellum is the second in importance; while the præscutum and the postscutellum are frequently but little developed. We find in the Hymenoptera that the scutum of the mesothorax is divided into three parts by two longitudinal sutures. The lateral portions of the scutum thus separated from the mesal part are termed the *parăpsides* (15*b*°).

Each pleurum is composed of two sclerites, arranged more or less obliquely. The cephalo-ventral one is the *epistĕrnum* (*e*); and the caudo-dorsal one the

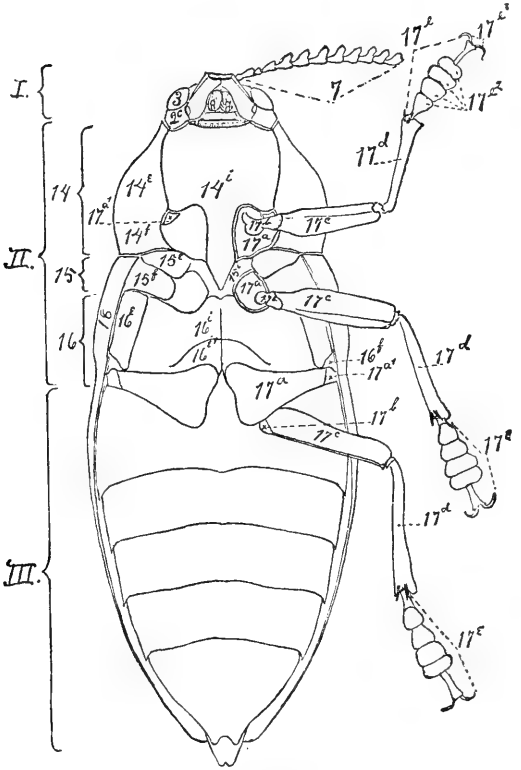


FIG. 34.—Ventral aspect of a beetle, *Enchroma gigantea*. (See Tabular Review, p. 23, for explanation of lettering.)

epimĕron (*f*). We find in many insects a third sclerite in each pleurum of the mesothorax and metathorax. These sclerites when present are situated near the base of the wing, and articulate with the dorsal margin of the episternum; they are the *parăptera* (*g*). In certain orders, especially Hymenoptera, the paraptera of the mesothorax are small, corneous, concavo-convex scales, which cover and protect the bases of the first pair of wings. By many writers these paraptera are termed the *tĕgulæ*, and by others the *scăpulæ*. In the Lepidop-

tera, the paraptera of the mesothorax are greatly developed. Here they appear as leaf-like epaulets, which sometimes cover not only the bases of the wings, but also the greater part of the mesonotum. In descriptive works on this order they are usually termed the *patāgia*.

In the membrane connecting the head with the prothorax there is on each side a pair of small sclerites. These are termed the *jūgular sclērites* (14*g*).

Each sternum is composed of a single sclerite. As indicated above, the three sterna are designated as the *prosternum* (14*i*), *mesosternum* (15*i*), and *metasternum* (16*i*) respectively.

In some beetles the metasternum is divided into two unequal portions by a suture which extends transversely a short distance in front of the caudal margin; the smaller sclerite which borders the posterior coxæ in front and often passes between them is called the *ante-coxal piece* of the metasternum.

The Appendages of the Thorax.

The appendages of the thorax are the organs of locomotion. They consist of the *legs* and the *wings*. Of the former there are three pairs; of the latter, never more than two. The distribution of these appendages has already been given (p. 16). The legs are joined to the body near the lateral borders of the sterna; the wings, near the lateral margins of the terga.

The Legs.—Each leg (17) consists of the following-named parts and their appendages: *coxa*, *trochanter*, *femur*, *tibia*, and *tarsus* (Fig. 34).

The Cŏxa.—The coxa (*a*) is the proximal segment of the leg. It is the one by means of which the leg is articulated to the body. It varies much in form, but is usually a truncated cone or nearly globular. In some insects the coxæ of the third pair of legs are more or less flattened and immovably attached to the metasternum (*e.g.* Carabidæ). In such cases the coxæ really form a part of the body-wall, and are liable to be mistaken for primary parts of the metathorax instead of the proximal segments of a pair of appendages.

In certain insects there is a small sclerite between the coxa and the epimeron. This is considered an appendage of the coxa, and is called the *trochăntin* (a^1). It is more often visible in the prothorax than in the other segments.

The Trochănter.—The trochanter (*b*) is the second part of the leg. It consists usually of a very short, triangular or quadrangular segment, between the coxa and the femur. Sometimes the femur appears to articulate directly with the coxa; and the trochanter to be merely an appendage of the proximal end of the femur (*e.g.* Carabidæ). But the fact is that in these insects, although the femur may touch the coxa, it does not articulate with it; and the organs that pass from the cavity of the coxa to that of the femur must pass through the trochanter. In the sub-order Terebrantia of the order Hymenoptera the trochanter consists of two segments.

The Fĕmur.—The femur (*c*) is the third part of the leg; and is usually the largest part. It consists of a single segment.

The Tibia.—The tibia (*d*) is the fourth part of the leg. It consists of a single segment; and is usually a little more slender than the femur, although it often equals or exceeds it in length. In such species as burrow in the ground, the distal extremity is greatly broadened and shaped more or less like a hand. Near the distal end of the tibia there are in most insects one or more spines which are much larger than the other hairs and spines which arm the leg; these are called the *tibial spines* or *tibial spurs*, and are much used in classification.

The Tarsus.—The tarsus (*e*) is the fifth and most distal part of the leg, that which is popularly called the foot. It consists of a series of segments, varying in number from one to six. The most common number of segments in the tarsus is five. The distal segment bears one or two claws (e^1). Sometimes these claws are strongly bifid or toothed; so that a tarsus may appear to bear four or even six claws. The tarsi vary much in form, and thus present characters which are useful in classification. Sexual characters are also frequently presented by this part.

On the ventral surface of the segments of the tarsus in many insects are cushions of short hairs or of membrane, capable of inflation, or concave plates, which act so as to produce a vacuum and thus enable the insect to walk on the lower surface of objects. These cushions or plates are called *pulvilli* (e^2). In many insects the pulvillus of the distal segment of the tarsus is a circular pad projecting between the tarsal claws. In most descriptive works this is referred to as *the* pulvillus, even though the other pulvilli are well developed. The pulvilli are also called the *onychii* by some writers.

With many insects (*e.g.* most Diptera) the distal segment of the tarsus bears a pair of pulvilli, one beneath each claw. In such cases there is frequently between these pulvilli a third single appendage of similar structure; this is called the *empodium*. In other insects the empodium is bristle-like or altogether wanting.

The proximal segment of the tarsus is designated in some descriptive works as the *metatarsus*.

The Wings.—The normal number of wings is two pairs; but in addition to the large order Diptera, there are many insects which have only a single pair; and many other insects are wingless. As already stated, the first pair of wings is articulated to the mesothorax; and the second pair, to the metathorax. When but a single pair of wings is present, it is almost invariably the first pair.

Each wing is a plate-like or membranous expansion which is first developed as a sac-like projection of the body-wall.* In the course of the formation of the wing, the dorsal and ventral walls of this sac become united throughout the greater part of their extent. There are usually certain lines along which the walls of this sac are thickened. The thickenings of the dorsal and ventral walls are exactly opposed, and together constitute the framework of the wing. These thickened lines are termed the *veins* or *nerves* of the wings; and their

* The gradual formation of wings can be easily observed in insects with an incomplete metamorphosis. See description of the transformations of the Acridiidæ.

arrangement is described as the *venation* or *neuration* of the wing. The terms veins and nerves are both in general use; and when applied to the wings of insects, have the same signification. Neither of them is good in this connection; but they are so firmly established that it would not be well to try to change them. The former, however, is the better. For in very many insects a groove extends along the ental surface of the thickenings of each wall; and the groove of the dorsal and ventral thickenings being exactly opposed, form a tube in the centre of each so-called vein or nerve, within which the fluids of the body circulate. In many insects these tubes, or *veins* as I shall call them, are also traversed by the air-vessels or tracheæ.

The thin spaces circumscribed by the veins are called *cells*.

An insect's wing is more or less triangular in outline; it therefore presents three margins (Fig. 35). To these special names have been applied; there is however, a lack of uniformity among entomologists in the terms which they use. The cephalic margin, Fig. 35, 1–2, is termed the *front margin*, *cŏstal margin*, or simply the *cŏsta*. The distal margin, Fig. 35, 2–3, is known as the *outer margin*, or *ăpical margin*. And to the caudal margin, Fig. 35, 3–4, are applied the terms *inner margin* and *ānal margin*.

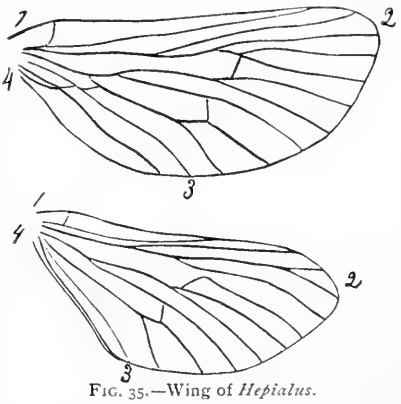


FIG. 35.—Wing of *Hepialus*.

The angle of the wing at the union of the cephalic and distal margins, Fig. 35, 2, is the *apex* of the wing; and the angle between the distal and caudal margins, Fig. 35, 3, is the *inner angle*. The proximal end of the wing is referred to as the base.

With certain insects (Hymenoptera and some Homoptera) the cephalic margin of the hind wings bears a row of hooks, which fasten into a corresponding fold on the caudal margin of the front wings. These hooks are named the *hămuli*, and serve to hold the two wings of the same side together, thus insuring their action as a unit.

In the moths the wings are united in a somewhat different way. On the lower surface of the front wing near its base there is a hook formed of either a portion of membrane or a tuft of hairs; into this hook there fits a bristle, the *frĕnulum*, which springs from the hind wing near its base. The frenulum is simple in the males; but it consists of several bristles in the other sex.

The wings present many characters which are much used in classification. These are variations in texture, form, clothing and venation.

The most striking variations in texture are presented by the first pair of wings. Special names have been applied to the wings exhibiting the more important of these variations. These are *elytra*, *hemelytrc*, and *tegmina*.

The Elytra.—The term *ĕlytra* is applied to the first pair of wings of beetles and earwigs. These wings are thick, horny or leathery, without veins or with merely traces of them, and when not in use they are horizontal, and meet

in a straight line on the middle of the back. The elytra are also called *wing-covers.*

The Hemĕlytra.—This term is applied to the first pair of wings when they are horny or leathery at the base and membranous at the apex, as in the Heteroptera.

The Tĕgmina.—This name is given to the mesothoracic wings when they are of an uniform leathery or parchment-like texture, and are furnished with veins. Of this form are the mesothoracic wings of Orthoptera. Like the elytra the tegmina are also called *wing-covers;* but unlike elytra they overlap each other when at rest.

The Hălteres, Balancers, or Poisers.—With most insects that possess only the first pair of wings (Diptera and the males of Coccidæ) the metathorax is furnished with a pair of appendages which are believed to be the homologues of the second pair of wings. These are called *hălteres, balancers,* or *poisers.* The halteres are usually club-shaped or thread-like, terminating in a knob. In the Coccidæ each of the halteres is usually furnished with a bristle which is hooked and fits into a pocket on the wing of the same side. In this case the halteres appear to aid in flight.

The Pseudo-halteres.—The insects belonging to the family Stylopidæ have only the metathoracic wings developed. The mesothoracic wings are represented by a pair of slender club-shaped appendages, which are termed *pseudo-halteres.*

Venation.—The number and situation of the veins of the wing afford characters which are much used in descriptive works. The variations presented by these characters are very great. And unfortunately no one has published an exhaustive work on the subject.* Much has been written upon it; but most of the writers have confined themselves to a single order or even family of insects. The result is that many systems exist; and frequently homologous veins bear different names in different groups of insects. It is necessary, therefore, in the study of any order of insects to learn the system or systems that have been established for that order. The more important of these are explained in the discussions of the orders in the following chapters of this work.

The Abdomen.

The *abdōmen* is the third or caudal region of the body. Its segments are more simple, distinct, and ring-like than those of the other regions. The number of segments of which it appears to be composed varies greatly. In the Cuckoo-flies (Chrysididæ) there are usually only three or four visible, while in many other insects nine appear. Except in the lowest order of insects (Thysanura) the abdomen of the adult bears no locomotive appendages. But many larvæ have fleshy appendages which aid in

* The most important of the attempts to work out the homologies of the wing veins is by Josef Redtenbacher. Ann. des K. K. Nat. Hofmuseums, I. (Wien, 1886). See Review in Am. Nat. vol. xxi. p. 932.

locomotion; these are termed *prōlegs*, and are shed with the skin when the larva changes to a pupa. In the adult the end of the body in many families is furnished with jointed filaments, the *cĕrci*, and *caudal sētæ*. Frequently also the body is furnished in the males with organs for clasping, the *claspers;* and in the females with saws, piercers, or borers, the *ovipŏsitor*. In the females of certain insects there is a *sting*, which is used as an organ of defence; and the abdomen of plant-lice and certain other insects bears a pair of tubes or tubercles, through which honey-dew is excreted; these are commonly called *honey-tubes;* they are also termed *cŏrnicles*, *nĕctaries*, or *sīphuncles*.

TABULAR REVIEW.

The numbers and letters preceding the names of parts are those by which these parts are designated in the figures illustrating this chapter. In some cases, where there is no danger of mistake, only the letters are used in the illustrations. Thus, in the figures of maxillæ, the cardo is indicated by *a*, not 11*a*.

- Body.
  - I. Head.
    - Fixed Parts of the Head.
    - Movable Parts of the Head.
  - II. Thorax.
    - Prothorax.
    - Mesothorax.
    - Metathorax.
    - (each) Fixed Parts. Appendages.
  - III. Abdomen.
    - Fixed Parts.
    - Appendages.

Fixed Parts of the Head.

1. Occiput.
2. Epicranium.
   - 2*a*. Front.
   - 2*b*. Vertex.
   - 2*c*. Genæ.
3. Eyes. (Compound Eyes).
4. Ocelli. (Simple Eyes).
5. Clypeus.
   - 5*a*. Ante-clypeus.
   - 5*b*. Post-clypeus.
6. Gula.

Movable Parts of the Head.

7. Antenna.
   - 7*a*. Scape.
     - 7*a*^{1}. Bulb.
   - 7*b*. Pedicel.
   - 7*c*. Clavola.
     - 7*c*^{1}. Ring-joints.
     - 7*c*^{2}. Funicle.
     - 7*c*^{3}. Club.
8. Labrum.
9. Epipharynx.
10. Mandible.
    - 10*a*. Prostheca.

11. Maxilla.
- 11*a*. Cardo.
- 11*b*. Stipes.
- 11*c*. Palpifer.
- 11*d*. Maxillary Palpus.
- 11*e*. Subgalea.
- 11*f*. Galea (Superior Lobe or Outer Lobe).
- 11*g*. Lacinia (Inferior Lobe or Inner Lobe).
- 11*h*. Digitus (Unguis).

12. Labium, or Second Maxillæ.
- 12*a*. Submentum (= Cardo).
- 12*b*. Mentum (= Stipes).
- 12*c*. Ligula.
  - 12*c*^{1}. Palpiger (= Palpifer).
  - 12*c*^{2}. Glossa (= Subgaleæ).
  - 12*c*^{3}. Paraglossa (= Galea).
  - 12*c*^{4}. ———— (= Subgalea).
- 12*d*. Labial palpi.

13. Hypopharynx.

Fixed Parts of the Thorax.

14. Prothorax.
- Dorsal Surface. (Pronotum.)
  - 14*a*. Præscutum.
  - 14*b*. Scutum.
  - 14*c*. Scutellum.
  - 14*d*. Postscutellum.
- Lateral Surface. (Pleura.)
  - 14*e*. Episternum.
  - 14*f*. Epimeron.
  - 14*g*. Jugular Sclerites.
  - 14*h*. Peritreme.
- Ventral Surface. (Sternum.)
  - 14*i*. Prosternum.

15. Mesothorax.
- Dorsal Surface. (Mesonotum.)
  - 15*a*. Praescutum.
  - 15*b*. Scutum.
    - 15*b*^{1}. Scutum.
    - 15*b*^{2}. Parapsides.
  - 15*c*. Scutellum.
  - 15*d*. Postscutellum.
- Lateral Surface. (Pleura.)
  - 15*e*. Episternum.
  - 15*f*. Epimeron.
  - 15*g*. Parapteron.
  - 15*h*. Peritreme.
- Ventral Surface. (Sternum.)
  - 15*i*. Mesosternum.

16. Metathorax.
- Dorsal Surface. (Metanotum.)
  - 16*a*. Præscutum.
  - 16*b*. Scutum.
  - 16*c*. Scutellum.
  - 16*d*. Postscutellum.
- Lateral Surface. (Pleura.)
  - 16*e*. Episternum.
  - 16*f*. Epimeron.
  - 16*g*. Parapteron.
  - 16*h*. Peritreme.
- Ventral Surface. (Sternum.)
  - 16*i*. Metasternum.
    - 16*i*^{1}. Ante-coxal piece. ————

APPENDAGES OF THE THORAX.

17. Leg.
- 17*a*. Coxa. — 17*a*¹. Trochantin.
- 17*b*. Trochanter.
- 17*c*. Femur.
- 17*d*. Tibia.
- 17*e*. Tarsus. — 17*e*¹. Claws. 17*e*². Pulvilli.

18. Wings.
- Membranous.
- Elytra.
- Hemelytra.
- Tegmina.
- Halteres.
- Pseudo-halteres.

Each of the above has:
- Borders: Cephalic. Distal. Caudal.
- Angles: Apex. Inner angle. Base.
- Veins. Cells. — A special nomenclature for each order.
- Hamuli.
- Hook and frenulum.

APPENDAGES OF THE ABDOMEN.

19. Pro-legs.
20. Cerci.
21. Caudal setæ.
22. Claspers.
23. Ovipositor.
24. Sting.
25. Honey-tubes.

THE INTERNAL ANATOMY OF INSECTS.

In order to obtain a clear idea of the relative positions of the different systems of organs in the body of an insect, let us recall the type of the Arthropoda described in the Introductory Chapter. A diagrammatic representation of this type is given in Fig. 36.

FIG. 36.—Diagram of structure of Arthropoda.

The body-wall is a hollow cylinder; within this the viscera are arranged as follows: The alimentary canal is central; the greater part of the nervous system, ventral; and the circulatory system, dorsal. To this simple conception it will be necessary to add a complicated respiratory system, not possessed by the lower Arthropods, and the muscular system and organs of reproduction, the discussion of which was omitted from the Introductory Chapter.

The Internal Skeleton.—Although the skeleton of an insect is chiefly an external one, there are prolongations of it into the body-cavity. As these form support for various organs, and attachment for many muscles, they are often described as the internal skeleton.

This internal skeleton becomes much more highly developed in adult insects than it is in larvæ. Special names have been applied to the parts of it in the head and the three thoracic segments. Thus the internal skeleton of the head is termed the *endocrānium* or *tentōrium;* and the principal parts of it in the thoracic segments, those which project from the sternal wall, are distinguished as the *antefūrca*, the *mediſūrca*, and the *postfūrca*. These are usually bifurcated; they support the nervous cord and give attachment to muscles.

The Minute Structure of the Body-wall.—Under the head of external anatomy the body-wall has been studied from one point of view. Reference was there made to the hardening of it by chitine, and a special study was made of the various sclerites. We have now to study the more minute structure of the body-wall, as seen on section with high powers of the microscope.

If a very thin section of the body-wall be taken and then dyed with the proper reagents, so as to differentiate the various parts, it will be seen under high powers of the microscope to consist of three principal layers; first, an outer chitinous layer, the *cuticle*, which forms the parts already studied; second, an intermediate cellular layer, the *hypodermis;* and third, a *basal membrane*.

The appearance of these layers is shown in Fig. 37. The chitinous layer is composed of many thin plates superimposed. It really consists of an excretion of the intermediate cellular layer. It is not composed of cells, but sometimes it is marked by lines corresponding to the outlines of the subjacent cells of the hypodermis. The hypodermis is composed of distinct nucleated cells; as it gives origin to the other parts of the skin, it is often termed the *mātrix*. The basal membrane is a thin sheet of homogeneous tissue.

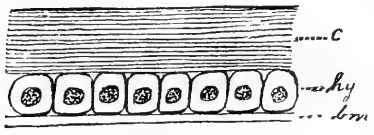
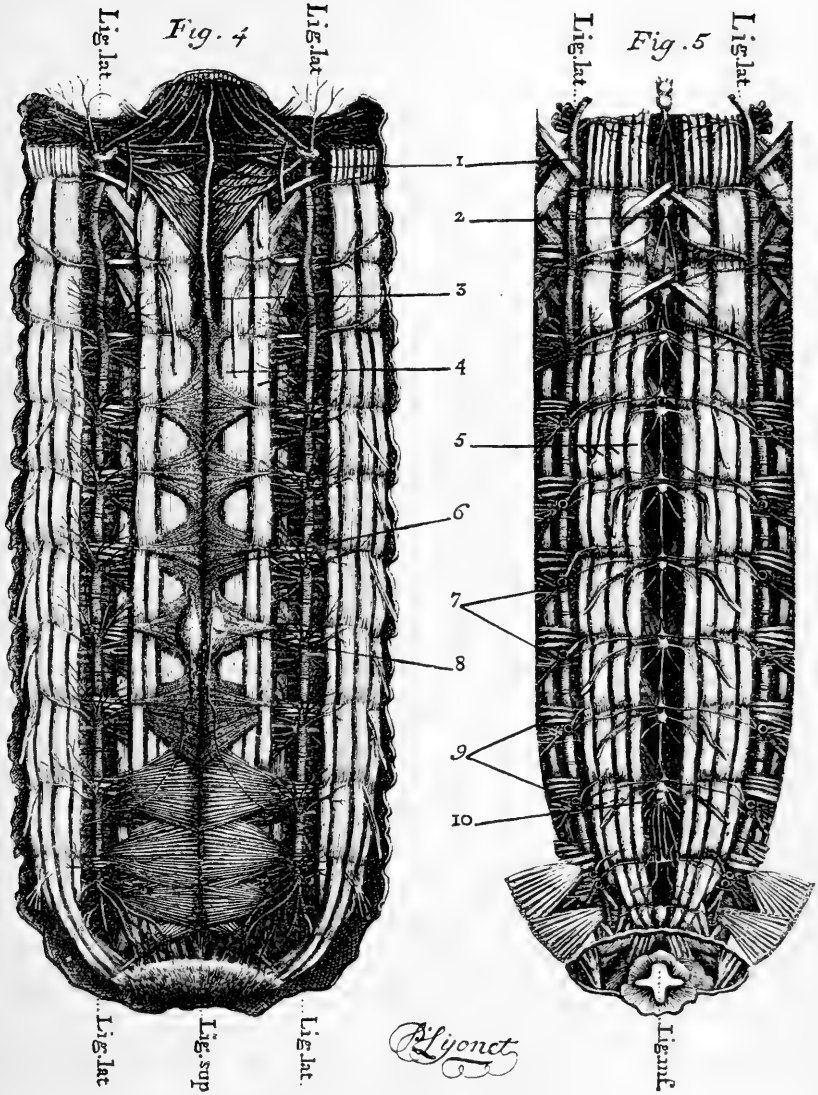


FIG. 37.—Section of body-wall.

The Muscular System.—The relative positions of the muscles and the skeleton in insects are very different from what they are in Man. With the Vertebrates, the bones constitute a central axis, outside of which the muscles are arranged. But in Insects, the skeleton of the body, and of any of its appendages as well, is a hollow cylinder, to the ental surface of which the muscles are attached. This is illustrated by Fig. 38, which represents the muscles in the leg of a beetle.

If the body of an insect (preferably of a larva) be opened by a longitudinal slit, and the alimentary canal removed from the centre,

PLATE I.



A CATERPILLAR (*Cossus ligniperda*).

(After Lyonet.)

Fig. 4. Caterpillar opened on the ventral middle line. Fig. 5. Caterpillar opened on the dorsal middle line. 1, principal longitudinal tracheæ; 2, central nervous system; 3, aorta; 4, longitudinal dorsal muscles; 5, longitudinal ventral muscles; 6, wings of the heart; 7, tracheal trunks arising near spiracles; 8, reproductive organs; 9, vertical muscles; 10, last abdominal spiracle.

a large part of the muscular system will be exposed to view. Plate I. represents the thorax and abdomen of a larva which has been prepared in this way. In these figures the band-like structures represented as lining the body-wall are muscles. And the number is much greater than shown here; for between these muscles and the body-wall there are in most places several layers of diagonal muscles.

The muscular system is composed of an immense number of distinct, isolated, straight fibres, which are always free (*i.e.*, not inclosed in tendinous sheaths as with Vertebrates). As a rule, the muscles that move the segments of the body are not furnished with tendons (Plate I.); while those that move the appendages are thus united at the distal end (Fig. 38). In appearance the muscles are either

FIG. 38.—Leg of May-beetle. (After Straus-Durckheim.)

colorless and transparent, or yellowish-white; and of a soft, almost gelatinous consistence. When properly treated with histological reagents, and examined with a microscope of moderately high power, they present numerous transverse striations, like the voluntary muscles of Vertebrates.

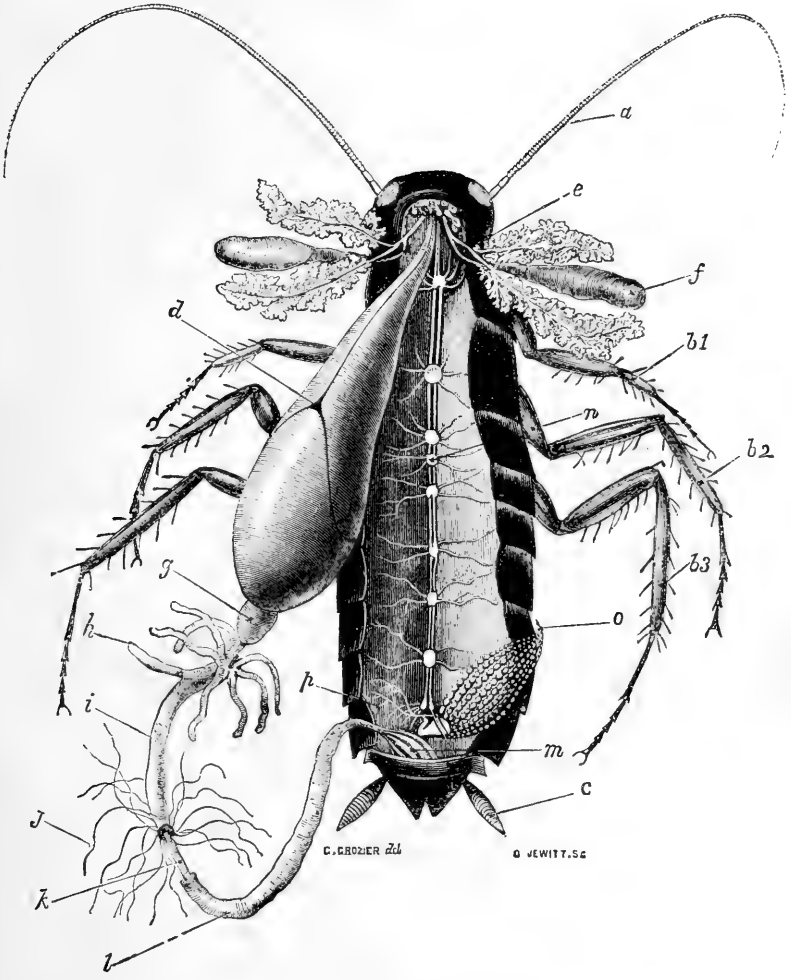
The Alimentary Canal.—In the ideal figure given on page 25, the alimentary canal is represented as a straight tube extending from one end of the body to the other. In the larva of some insects there is an approach to this degree of simplicity. But usually the tube is longer than the body, and is consequently more or less convoluted. Moreover, it is not of uniform structure, but, as in the higher animals, different parts are adapted to different functions. Names have been applied to these special parts similar to those used to designate the analogous parts in higher animals. These are as follows:

There is within the head a portion of the alimentary canal that is usually more or less enlarged; this is the *phărynx*. It has been shown recently * that in some sucking insects the pharynx is furnished with powerful muscles, by which it can be distended, and that it is doubtless the pumping organ, by which these insects

* Edward Burgess, Contributions to the Anatomy of the Milkweed Butterfly (Memoirs of the Boston Society of Natural History, 1880).

George Dimmock, The Anatomy of the Mouth-parts and Sucking Apparatus of some Diptera (Boston, 1881).

PLATE II.



A Cockroach (*Periplaneta orientalis*).

(From Rolleston.)

a, antennæ; b_1, b_2, b_3, tibiæ; *c*, anal cerci; *d*, ganglion on recurrent nerve upon the crop; *e*, salivary duct; *f*, salivary bladder; *g*, gizzard; *h*, hepatic cœca; *i*, chylific stomach; *j*, Malpighian vessels; *k*, small intestine; *l*, large intestine; *m*, rectum; *n*, first abdominal ganglion; *o*, ovary; *p*, sebaceous glands.

obtain their food. We do not know yet how generally this is true of sucking insects.

Following the pharynx and extending into or through the thorax is a slender part, the *œsŏphagus.*

In many insects, both sucking and biting, there is a dilation of the œsophagus near its caudal end, which serves as a reservoir of food, and is termed the *crop.* The crop of sucking insects was formerly thought to be the pumping organ, and is, therefore, described in the older works on this subject as the sucking stomach.

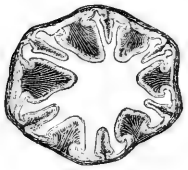


FIG. 39.—Cross-section of the proventriculus of *Corydalus.*

Following the crop we find in some insects a compact enlargement of the alimentary canal with strong muscular walls, the *proventrĭculus* or *gizzard.* This is sometimes a very complicated organ, furnished with teeth, spines, and hairs, for the grinding of the food. (Fig. 39.)

The *stomach* is next in order, and is easily recognized by its central position, and usually by its large size. It is also known as the *ventrĭculus*, or *chylĭfic vĕntricle.*

The remaining part of the alimentary canal is the *intĕstine.* This is often composed of three specialized regions, named, as in the higher animals, the *ĭleum* or small intestine, the *cōlon* or large intestine, and the *rĕctum.*

There may be several sets of appendages to the alimentary canal. The first of these are the *sălivary glands*, which open near the mouth. These glands vary greatly in form and number, and are sometimes wanting. In Lepidopterous larvæ they constitute the *silk glands*, and, in this case, have a distinct opening through the modified labium or "spinneret." At the beginning of the stomach, there are in many insects several pouch-like appendages, the *cæcal tubes.* These secrete a digestive fluid, which resembles the pancreatic juice of Vertebrates. Usually the most conspicuous of the appendages of the alimentary canal are certain long, slender tubes opening into the beginning of the small intestine, and floating free in the body-cavity or lying upon the surface of the stomach. These are named the *Malpĭghian vessels*, in honor of Malpighi, an anatomist who wrote more than two hundred years ago. Formerly they were supposed to be biliary vessels; but their function has been determined to be urinary. There are other glandular appendages, which, as they open into the alimentary canal near its caudal opening, are termed *ānal glands.* These probably do not constitute a

part of the digestive system, but are organs of offence, the secretion being acrid or otherwise offensive.

Insects take the greater part of their food during the larva or nymph state; for it is in this period that they acquire their growth. In some cases, as with the May-flies and the Bombycid moths, no nourishment is taken during the adult state. With certain larvæ (larvæ of the higher Hymenoptera, Pupipara, and Ant-lions), the stomach ends blindly, and does not communicate with the intestine. In the Ant-lions the rectum is transformed into a silk gland; and the silk of which the cocoon is made is spun from the anus.

The Adipose Tissue.—On opening the body of an insect, especially of a larva, one of the most conspicuous things to be seen is fatty tissue in large masses. These often completely surround the alimentary canal, and are held in place by numerous branches of the tracheæ with which they are supplied. Other and smaller masses of this tissue adhere to the inner face of the abdominal wall, in the vicinity of the nervous system, and at the sides of the body. It also abounds in the pericardial sinus. In a full-grown larva of *Corydalus cornutus* I have found the adipose tissue to be greater in bulk than all of the other organs found inside of the muscular walls of the body. In adult insects it usually exists in much less quantity than in larvæ.

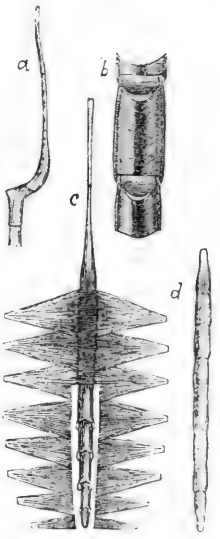


Fig. 40.—Heart of May-beetle (after Straus-Durckheim). *a*, lateral aspect of aorta; *b*, interior of heart showing valves; *c*, ventral aspect of heart and wing-muscles—the muscles are represented as cut away from the caudal part of the heart; *d*, dorsal aspect of heart.

The Circulatory System.—In insects the circulatory system is not a closed one, the blood flowing in vessels during only a part of its course. The greater part of the circulation of this fluid takes place in the cavities of the body and its appendages, where the blood fills the space not occupied by the internal organs. The only blood-vessels that exist in these animals lie just beneath the body-wall, above the alimentary canal (Fig. 36, *h*). They extend from near the caudal end of the abdomen through the thorax into the head. That part of this system that lies in the abdomen is usually termed the *heart*, and consists of a series of chambers corresponding to the segments of the body (Fig. 40, *d*). The number of these chambers varies, but it is rarely more than eight.

Miall and Denny, however, describe the heart of a cockroach as consisting of thirteen chambers, corresponding to ten abdominal and three thoracic segments. The chambers of the heart are separated by valves, which permit the blood to flow only towards the head. There is in the walls of the heart a pair of lateral openings corresponding to each chamber; these also are furnished with valves, which admit the blood to the heart, but prevent its exit. When, therefore, the chambers contract, a stream of blood is forced towards the head; and when they expand, the blood rushes into them through the lateral openings.

The circulatory system has been carefully studied in only a few insects; and these show a remarkable variation in the form and arrangement of the openings and valves.* But the result of their operation is the same in all. A diagram of a horizontal section of the heart of a May-beetle, based on the description by Straus-Durckheim (Graber represents it as more complicated) will serve as an illustration. Fig. 41, *S*, represents a chamber of the heart during its systole or contraction; the valves at the caudal end and at the lateral openings (1) have been closed by the pressure of the blood; while the valves at the cephalic end have been forced open, and the blood, represented by the arrow, is flowing forwards. *D* represents a chamber regaining its natural size, and the blood flowing into it through the lateral openings.

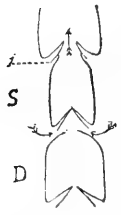


FIG. 41.—Diagram of heart of May-beetle.

I have observed a somewhat different arrangement of openings and valves in the nymph of a dragon-fly. A young individual was studied, one in which the skin was sufficiently transparent to allow the beating of the heart to be seen through it. In this insect the most active part of the heart appeared to be the caudal chamber, which is represented in Fig. 42, *a*. This chamber was in constant motion, expanding and contracting in rapid succession. With each expansion the valves at 1 quickly closed and the blood rushed in at 2; and when the chamber contracted, the valves at 2 closed and the blood was forced forwards through 1.

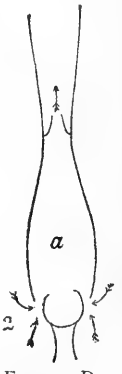


FIG. 42.—Diagram of caudal chamber of heart of Dragon-fly.

* See Dr. V. Graber, Ueber den propulsatorischen Apparat der Insecten, Archiv für mikroscopische Anatomie, Band IX. (1873).

Straus-Durckheim, Animaux Articules (1828).

Miall and Denny, The Cockroach (1886).

In many insects, instead of a rapid alternation of contraction and expansion of the chambers, the heart begins to contract at its caudal end, and a wave of contraction passes towards the head along the entire length of the organ; frequently one wave will pass the entire length of the heart before another begins.

The cephalic prolongation of the heart, which extends through the thorax and into the head, is a simple tube, the *aŏrta* (Plate I., 3; Fig. 40, *c* and *a*). The aorta ends in the head, near the brain, where it is usually somewhat branched. The branches are very short, and the blood passes from them directly into the body-cavity. Here it bathes the viscera, receiving the products of digestion from the alimentary canal, giving up to the various glands their secretions, and carrying nourishment to all parts of the body. In its course through the body the blood flows in regular channels, without walls, like the currents of the ocean.

The blood is usually colorless, or slightly tinged with green; but its circulation is made conspicuous by the movements of the large corpuscles with which it abounds. In transparent insects it can be seen pouring forth from the cephalic end of the aorta, bathing first the brain, and then passing to all parts of the body, even out into the appendages. By tracing the course of any one of these currents it will be found to flow sooner or later to the sinus in which the heart rests, and from which it receives its blood.

The Pericărdial Sīnus, to which reference has just been made, is separated from the general cavity of the body by a membrane, the *pericardial diaphragm*. This diaphragm is perforated by many openings, through which the blood passes on its return to the heart. Into the diaphragm there are inserted a double series of triangular muscles (Plate I., 6; and Fig. 40, *c*). These meet on the middle line, and are attached by their smaller ends to the lateral walls of the body. They were formerly supposed to be attached to the sides of the heart, and to aid in the expansion of that organ; they were, therefore, named by Lyonet the *wings of the heart*. The relation of these muscles to the heart is shown in Fig. 43, which is a diagram of a cross-section of the body. In this *w* represents the position of the wings of the heart. I do not think that the use of these muscles has yet been fully determined. One function, though probably a subordinate one, is doubtless to protect the heart from pressure. One has only to watch the peristaltic movements of the alimentary canal in a transparent larva to appreciate the importance of this.

FIG. 43.—Diagram of wings of the heart.

The Nervous System.—The central part of the nervous system, as already indicated, consists of a ganglion in the head above the œsophagus, and of a series of ganglia (typically one for each segment of the body) lying on the floor of the body-cavity, and connected by two longitudinal cords. In the head, one of these cords passes on each side of the œsophagus, from the brain to another ganglion in the head below the œsophagus, thus forming a nervous collar about the alimentary canal. From each ganglion nerves arise, which supply the adjacent parts; and from the thoracic ganglia nerves extend to the legs and wings. This series of ganglia is really a double one; but each pair of ganglia are more or less closely united on the middle line of the body, and often appear as a single ganglion. Fig. 44 gives a general view of the nervous system of *Corydalus cornutus* as represented by Leidy. From the brain (*a*) two large nerves extend to the compound eyes, and a smaller pair to the antennæ; the sub-œsophageal ganglion (*b*) supplies the mouth-parts with nerves; and each of the thoracic and abdominal ganglia supplies its segment of the body.

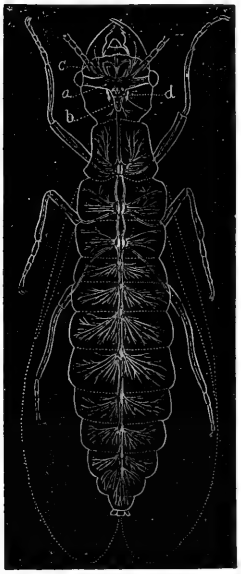


FIG. 44.—Nervous system of *Corydalus.*

In *Corydalus* (Fig. 44) the eighth and ninth pairs of abdominal ganglia are united, and drawn cephalad into the seventh abdominal segment. The same thing is presented by the larva of *Cossus* (Plate I., 10). This is an illustration of what has been termed cephalization of the nervous system. In the adults of insects of the higher orders this cephalization of the nervous system is carried to a great extent. In some cases the abdominal ganglia are fused into a common mass and drawn cephalad into the thorax. Between this and the form presented by *Corydalus* every gradation exists. With the higher insects the nervous system undergoes marked changes during the life of the individual. In a caterpillar it is of the form shown in Plate I.; in the pupa state it becomes somewhat shortened; and in the adult the abdominal ganglia are all or nearly all united with the thoracic ganglia into a common nervous mass.*

* See figures by Newport, Cycl. Anat. and Phys. II. pp. 963–965.

In addition to the central nervous system described above, there is what has been termed the *visceral nervous system*. This consists of two parts,—the *œsophageal nerves*, and the *respiratory nerves*.

There are two sets of œsophageal nerves,—the *unpaired* and the *paired*. From each of the nerve-cords that connect the brain with the subœsophageal ganglion there arises a nerve, which extends cephalad upon the œsophagus; these unite to form the frontal ganglion (Fig. 44, *c*).* From this ganglion a recurrent nerve passes caudad through the œsophageal collar between the aorta and the œsophagus. A short distance caudad of the brain, this nerve, in some insects, enters a small ganglion, from which branches extend to the sides of the alimentary canal; in other insects it forms a number of plexuses in the muscular layer of that organ without apparent ganglia. These ganglia and nerves comprise the unpaired system. The paired œsophageal nerves arise on either side from the caudal aspect of the brain, and swell out at the sides of the œsophagus to form ganglia (Fig. 44, *d*) which also supply nerves to the walls of the alimentary canal.

The respiratory nerves are not represented in the figure of *Corydalus;* but they are well shown in that of the larva of *Cossus* (Plate I.). They consist of the following parts: In each segment of the thorax and abdomen there is a short longitudinal cord between the two cords of the central nervous system. Each of these cords enlarges into a ganglion, from which branches extend laterally to the sides of the body, where they supply the tracheal trunks and the muscles of the spiracles.

The Organs of Special Sense.—It is probable that insects possess the five senses known to us; and perhaps they have others the nature of which we cannot conceive. Even in the case of the five senses, the range of perception may be very different from ours. Thus Lubbock has shown that ants perceive the ultra-violet rays, which are invisible to us. There is, however, a great variation in the degree of development of the different senses in different insects; for example, some are furnished with wonderful eyes, while others are blind. It is probable that in many cases the great development of one sense is correlated with a slight development of some other. As an illustration, we find that in the Dragon-flies and Cicadas, which are essentially directed by sight, the antennæ are rudi-

* See *William C. Krauss*, On the Nervous System of the Head of the Larva of Corydalus cornutus: an extract from a thesis in Entomology presented to the faculty of Cornell University for the Baccalaureate in Science: *Psyche*, vol. IV. pp. 179–184.

mentary, and doubtless the sense of smell likewise. During the night these insects are passive, while during the day they trust to their powers of sight, or possibly in some Cicadas also to hearing.

The study of the sensations of insects is at the same time one of the most difficult and one of the most interesting of the departments of entomology. But as yet comparatively little has been done in this line. The great improvements that have recently been made in the methods of histological research have resulted in the publication of several very important papers on the structure of sense-organs; but there is a great lack of experimental basis for conclusions as to the functions of the various organs that have been described.*

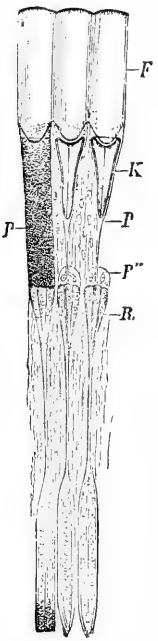


FIG. 45. — Three ocelli with retinulæ from the compound eye of a May-beetle. (After Grenacher.) The pigment has been dissolved away from two of them. *F*, corneal facet; *K*, crystalline cone; *P*, pigment-sheath; *P*, chief pigment-cell; *P''*, pigment-cells of the second order; *R*, retinulæ.

The best known of the organs of special sense are the *organs of sight*. Of these there are two kinds, the simple eyes and the compound eyes. Simple eyes exist in both larvæ and adult insects. In the former there may be several of these, on each side of the head; in the latter there are usually not more than three, situated between the compound eyes. The compound eyes occur only in adult insects, where they reach a marvellous degree of complexity. Each compound eye consists of many ocelli united; the number varies from 50 in some ants to more than 30,000 in certain butterflies. The complexity of these eyes does not, however, consist merely of the great number of ocelli that enter into the composition of each; but each ocellus is a highly developed organ consisting of many parts. The structure of these ocelli varies greatly in different insects.† Fig. 45 represents three ocelli of a May-beetle as described by Grenacher.

With regard to the organs of special sense other than those of sight there is much doubt. It is probable that many insects possess *organs of hearing;* for elaborate sound-producing organs are common among them. But the only

* For a general discussion of this subject, and for many references to the literature, see *Expériences et Remarques critique sur les Sensations des Insectes, par Auguste Forel, Recueil Zoologique Suisse*, t. IV. (1886).

† See B. T. Lowne, On the Modifications of the Simple and Compound Eyes of Insects (Philos. Trans. 1878); also the works cited by this author.

organs of insects that are generally believed to be ears are the so-called tympanal organs of Orthoptera, which are placed at the sides of the first abdominal segment in the Acrididæ, and near the proximal end of the tibiæ of the first pair of legs in the Locustidæ and Gryllidæ; and even in the case of these it is not proven that they have the function of hearing.

As to the *sense of smell* many conflicting views are held;* but the weight of opinion now is that certain antennal structures are the organs of smell. These structures are to be found in the antennæ of many insects. If, for example, the surface of the plates that compose the club of the antennæ of a May-beetle be examined it will be found to be thickly studded with pits. These can be seen with a

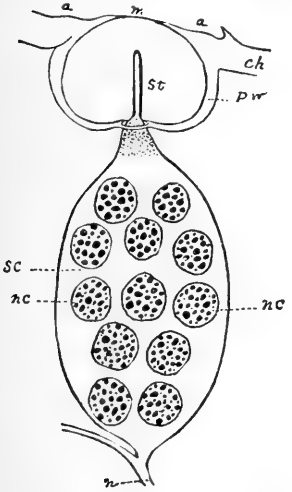


FIG. 46.—Organ of smell of *Caloptenus*. (After Hauser.)

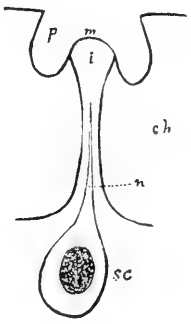


Fig. 47.—Organ of smell of May-beetle. (After Hauser.)

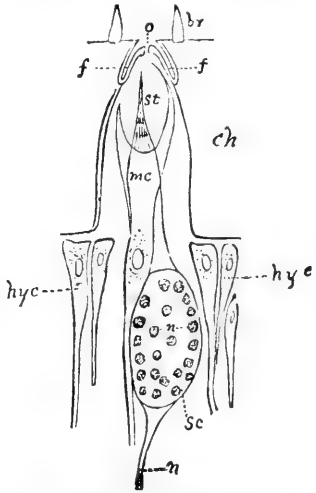


Fig. 48.—Organ of Smell of *Vespa*. (After Hauser.)

Lettering of Figs. 46, 47, and 48.—aa, circular thickening of the skin surrounding the opening of the olfactory pit; *br*, bristle; *ch*, chitinous integument of the antennæ; *f*, invaginated pit; *hyc*, hypodermic cells; *i*, entrance into the canal belonging to the pit; *m*, olfactory membrane; *mc*, membrane-forming cell; *n*, nerve of special sense; *nc*, nucleus of the sense- or ganglion-cell; *o*, opening into the olfactory pit; *p*, olfactory pit; *pw*, wall of the pit; *sc*, sense- or ganglion-cell; *st*, olfactory or sense-style, sometimes peg-shaped.

microscope of low power; but in order to determine the minute structure of the organs thin sections of them must be made and examined with high powers. Fig. 47 represents a section of one of these pits; and Figs. 46 and 48 represent the corresponding organs in a locust and in a wasp.† The form of these organs of smell varies

* See Packard's abstract of a paper upon this subject by Dr. K. Kraepelin, *American Naturalist*, 1886, pp. 889 and 973.

† See Hauser, On the Organs of Smell in Insects, translated by Packard, *American Naturalist*, 1887, p. 279.

greatly in different insects, as is shown by the accompanying figures.*

What are supposed to be *organs of taste* in Hymenoptera and Diptera have been carefully described by Will.‡ These consist of pits on the labium and on the lower side of the maxillæ through

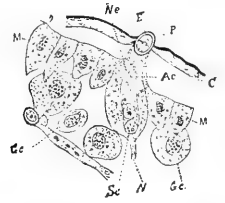


FIG. 49.—Organ of taste in the labium of *Vespa vulgaris*. (After Will.)

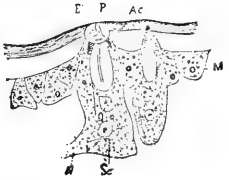


FIG. 50.—Similar organ in maxilla of the same insect. (After Will.)

Lettering of Figs. 49 and 50.—*C*, cuticle; *P*, pit in the same; *Sc*, sense-cell; *Ne*, neurilemma of sense-cell; *Ac*, axis cylinder of sense-cell; *E*, end of the same; *N*, nerve connected with sense-cell; *M*, matrix-cells; *Gc*, gland-cells.

which ends of nerves come to the surface. The structure of these organs in *Vespa vulgaris* is shown in Figs. 49 and 50.

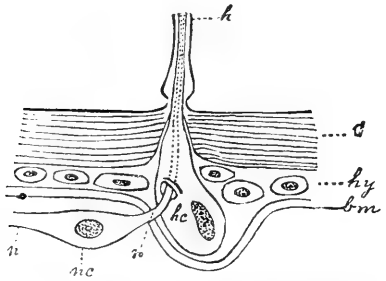


FIG. 51.—Diagram of tactile hair. *c*, cuticle; *hy*, hypodermis; *bm*, basal membrane; *h*, hair; *hc*, hair-cell; *n*, nerve; *nc*, nerve-cell.

It is probable that *organs of touch* are well developed in many insects. Leydig, Hicks, and Viallanes have described tactile hairs, which are situated upon pores in the cuticle, in which nerves end. Figure 51 is a diagram of one of these hairs.

The Respiratory System.—If an insect be carefully examined there can be found along the sides of the body a series of openings. These can be easily seen in many caterpillars and other larvæ; they are the openings of the respiratory system, and are termed the *spiracles*.

The number of spiracles varies greatly in different insects. There is, however, never more than one pair on a single segment of the body. They do not occur on the head, but are borne by each of the thoracic segments, and by the first eight abdominal segments. Thus there are eleven segments that may bear spiracles; but they are always lacking on some one or more of these.

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* For generalizations regarding these organs see Kraepelin, translated by Packard, *American Naturalist*, 1887, p. 182.

‡ Will, F. Das Geschmacksorgan der Insekten. Zeitschrift für Wissen. Zool. 1885, p. 674.

These spiracles are either simple openings into the respiratory system, or are provided with valves, sieves, or fringes of hair for the exclusion of dirt. They lead into a system of air-tubes termed *trācheæ*. The accompanying figures will indicate the distribution of the main trunks of these tracheæ in a cockroach. There is a short trunk arising from each spiracle; these are all connected together by a large longitudinal trunk on each side of the body, and by numerous transverse trunks. From these large tracheæ there arise a great number of smaller ones, not shown in the figures, which branch and subdivide, and extend to all parts of the body. When one dissects an insect the viscera are found to be connected together by the ramifications of these tracheæ, so that in order to remove any organ it is necessary to cut some of them. The smaller branches of the tracheæ are exceedingly minute, and are intimately

FIG. 52.—Tracheal system of Cockroach. The dorsal integument removed and the alimentary canal in place. (After Miall and Denny.)

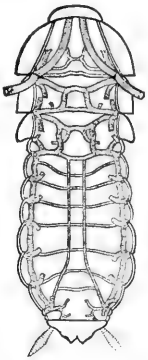

FIG. 53.—Tracheal system of Cockroach. The alimentary canal removed to show the ventral tracheal communications. (After Miall and Denny.)

associated with the various tissues. By means of these fine tracheal trunks the air is carried to the various tissues; so that they are supplied with oxygen directly from the air, without the intervention of blood as in the higher animals.

The minute structure of the tracheæ has been the source of much discussion. But at last it seems to be well understood. The walls of the tracheæ are composed of three layers, which correspond to the layers of the body-wall. In fact the tracheæ are looked upon as invaginations of the body-wall. The continuity of the membranes of the tracheæ and body-wall is shown diagrammatically in Fig. 54. It should be observed that it is the inner layer of the wall of the trachea that corresponds with the outer layer of the wall of the

body. This inner layer of the wall of the trachea, the *intima*, like the cuticle is chitinous, and is shed from the tracheæ with the cuticle when the insect moults. There is a peculiarity in the structure of the chitinous layer of the wall of the tracheæ that has attracted much attention. It is furnished with thickenings which extend spirally. These give the tracheæ their characteristic transversely striated appearance. If a piece of one of the larger tracheæ be pulled apart the intima will tear between the folds of the spiral thickenings, and the latter will uncoil from within the trachea like a thread. In some insects there are several parallel thickenings of the intima; so that when an attempt is made to uncoil the thread a ribbon-like band is produced, composed of several parallel threads. I have often observed this in the larger tracheæ of the larva of *Corydalus*. The spiral threads are wanting in the smaller terminal portions of the tracheæ.

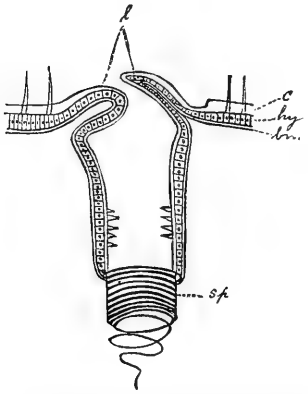

FIG. 54. — Section of trachea and body-wall. *c*, cuticle; *hy*, hypodermis; *bm*, basal membrane; *sp*, spiral thickening of the intima.

In many adult insects, especially those that have great powers of flight, the tracheæ are enlarged in many places so as to form air-sacs. These doubtless tend to lessen the specific gravity of the insect. The spiral thickenings are not developed in the intima of these air-sacs.

Although insects are, strictly speaking, air-breathing animals, many of them, as is well known, live in the water. The study of the ways in which aquatic insects breathe is a very interesting one; it presents to us many wonderful modifications of structure. Some of the more common of these are described in subsequent pages of this book; in this place I can only make a few generalizations.

The various modes of respiration of aquatic insects may be classified under two heads: first, those in which the insect obtains its air from above the surface of the water; second, those in which the insect breathes the air that is mechanically mixed with the water.

With many aquatic insects the spiracles open beneath the wings, which are folded upon the abdomen. The insect by coming to the surface of the water and lifting the tips of its wings forms a cavity beneath them into which the air rushes. The insect can then swim through the water carrying this air with it in a position where it can be respired. When the air becomes impure, the insect rises to the

surface, forces out the air from beneath its wings and takes in a new supply. Water-beetles and aquatic bugs afford familiar examples of this mode of respiration.

Some insects are provided with long tubes connected with their spiracles by means of which they can draw their supply of air from above the surface of the water while they crawl upon the bottom of shallow ponds. Our most common illustrations of this are bugs of the family Nepidæ; but the most remarkable development of this kind is exhibited by certain Dipterous larvæ of the family Syrphidæ, known as Rat-tailed Maggots.

Although there are many insects that live in the water and draw their supply of air from above it, the greater number of aquatic insects breathe, as do fishes, the air that is mixed with the water. This is accomplished by organs known as tracheal gills. These are hair-like or more or less plate-like expansions of the body-wall, abundantly supplied with tracheæ. These tracheæ divide and subdivide, and their terminations or fine branches are separated from the water that bathes the organ only by its thin walls. In this way the air contained in the tracheæ is separated from the air in the water only by a delicate membrane which admits of the transfer of gases between them. It will be observed that the difference between a tracheal gill and a true gill (as of fishes, crustacea, etc.) is that the true gill is supplied with vessels containing blood, which is purified by being brought in contact with the air in the water, while the tracheal gill is supplied with tracheæ containing air to be purified.

Tracheal gills are usually borne by the abdomen, sometimes by the thorax, and in case of one genus of Stone-flies by the head. They pertain almost exclusively to the immature stages of insects; but Stone-flies of the genus *Pteronarcys* retain them throughout their existence.

Tracheal gills vary greatly in form; in *Corydalus* they are hair-like and occur in tufts near the lateral margins of the abdominal segments; in the Caddice-worms they are thread-like, more or less branched, and irregularly distributed over the surface of the abdomen; and in certain Dragon-flies (Agrioninæ) they are in the form of large plate-like caudal appendages, Fig. 55.

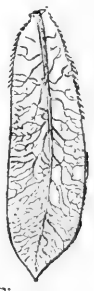

Fig. 55.—Tracheal gill of *Agrion*

The respiratory movements of insects have been carefully studied by Plateau* and others. These movements consist in general of

* See account by Plateau, in "The Cockroach," by Miall and Denny, p. 159.

alternate contraction and recovery of the figure of the abdomen in two dimensions, viz., vertical and transverse.

The Reproductive Organs.—In insects the male and female reproductive organs are placed in different individuals. In many insects there are marked external sexual differences of size, form, coloring, or character of appendages. In others it is difficult to determine the sex without dissection. The reproductive organs vary greatly in form, but agree in certain general characteristics. They are contained in the abdomen, are paired, and usually open by a common duct near the caudal end of the body. (In the May-flies and Earwigs the reproductive organs of each side have a distinct opening.)

In the female there is in the abdominal cavity on each side an *ōvary*. This is a compound organ consisting of a series of parallel tubes opening into a common *ōviduct*. Sometimes these tubes are attached to each other so as to form a compact body; in other species each tube is free for a greater or less part of its length. These tubes are tapering in outline, the larger end being joined to the oviduct. Within these tubes, even in the larval state, may be found the developing eggs, each tube containing a single row of them gradually increasing in size from the small end of the tube towards its opening into the oviduct. The oviducts of the two sides unite a short distance from the external opening and form the *vagīna*. There are usually accessory glands opening into the vagina, whose secretions serve to surround the eggs or to fasten them to the objects upon which they are laid. Connected also with the vagina are one or more pouches, the *receptăcula sĕminis*, within which the reproductive fluid of the male is received and stored. This fluid retains its fertilizing properties for a long time. Thus the queen-bee or ant pairs but once, though she may continue to lay fertile eggs for years. The fertilization of the eggs of insects takes place at the time they are laid. There is in one end of the shell of the egg one or more pores known as *mīcropyles*. Through these the spermatozoa enter the egg, as it passes the opening of the receptacula seminis.

In some cases, at least, it is not necessary that an egg should be fertilized in order that the embryo should develop. This has been proven with the Honey-bee. But so far as is known the unfertilized eggs of the bee produce only males.

The organs of the male consist of a number of tubular glands, often coiled together so as to form an apparently compact body, the *tĕstes*. These like the ovaries are paired and located in the abdominal cavity. The efferent ducts of these glands, the *vāsa defe-*

rĕntia, like the oviducts unite and form an unpaired duct, *the dŭctus ejaculatōrius*. Accessory glands open into this duct.

All insects are developed from eggs. But there are some apparent exceptions. Thus many flies retain their eggs till after they are hatched, if a proper place for laying them is not found earlier; and in some flies (the Pupipara) the young attain a considerable development before they are born. In the Plant-lice (Aphididæ) there is a remarkable alternation of reproduction by budding with the sexual reproduction.

CHAPTER III.

THE ORDERS OF THE HEXAPODA.

In a preceding chapter the distinguishing characters of insects have been discussed. We have now to study the manner in which the class Hexapoda is divided into its principal divisions or orders. Regarding this subject, there is at the present time much difference of opinion. Naturalists are not agreed as to the limits of the different orders of insects. The number recognized in standard works varies from seven to more than twice that number.

Although the question is an exceedingly difficult one, it is an easy matter to state where the differences of opinion lie. And these differences do not complicate the subject greatly.

More than a century ago Linnæus recognized seven orders of insects. These he named Coleoptera, Hemiptera, Lepidoptera, Neuroptera, Hymenoptera, Diptera, and Aptera. Five of these orders were well founded; and two were not. The Aptera was soon regarded as an unnatural group. It included various wingless insects, which later entomologists have distributed among the other orders. The Linnæan order Hemiptera included all four-winged insects in which the front wings are half horny and half membranous. But here Linnæus by confining his attention to the wing characters alone fell into error. The order Hemiptera as defined by him included at least two distinct orders; and those members of it with biting mouth-parts were separated a little later by Olivier as the order Orthoptera. Thus by the suppression of the Aptera, and the erection of the Orthoptera, the number of orders remained the same as proposed by Linnæus. And with these two modifications the Linnæan classification has been very generally accepted to this day.

The modified Linnæan system indicated above is very simple and for this reason many entomologists are loath to propose alterations in it. But there are certain places in which this classification brings together insects which differ too widely to be classed in the same order. The science of Entomology, however, is not yet far enough advanced for any one to state with any degree of certainty in just how many cases this is true.

One of the principal points in which there are differences of

opinion is in regard to the order Neuroptera. In this order as defined by Linnæus there are included insects with a complete metamorphosis as well as those with an incomplete one. So radical a difference as this can hardly be expected to occur within the limits of the same order.* For this reason those families in which the transformation is an incomplete one were separated by Erichson as the order Pseudoneuroptera; and the term Neuroptera restricted to those in which the metamorphosis is complete. This adds one to the list of orders. In the following pages I have considered the order Pseudoneuroptera, as distinct from the order Neuroptera.

Gerstaeker and some others of the German entomologists do not stop with the separation of the Pseudoneuroptera from the Neuroptera. They hold that there is no important character separating the former order from the Orthoptera; and they therefore include in the order Orthoptera not only the insects commonly placed there by the English and American entomologists, but also those of the Linnæan order Neuroptera in which the metamorphosis is an incomplete one.

We have, therefore, three slightly differing systems, which agree as to the orders Hemiptera, Lepidoptera, Diptera, Coleoptera, and Hymenoptera, but differ as to the other orders. These differences are represented in the following table. It will be noted that although the classification of Olivier and that of Gerstaeker present the same names, these are used with widely different signification. The Orthoptera of Gerstaeker includes much more, and the Neuroptera much less than in the classification of Olivier.

OLIVIER.	ERICHSON.	GERSTAEKER.
Orthoptera.	*Orthoptera.*	*Orthoptera.*
Neuroptera.	*Pseudoneuroptera.*	
	Neuroptera.	*Neuroptera.*

Although the Linnæan system slightly modified in one or another of the three ways just indicated is still very generally accepted, there are many entomologists who hold that further modifications should be made. There are certain families, as the Earwigs, Fleas, Thrips, and others, each of which differs greatly from the typical representatives of the order in which it was at first placed. Each of these families have in turn been raised to the rank of an order. But there is as yet little agreement among systematists as to how

* The males of the Coccids are the only insects which present an exception in this respect.

many of them are entitled to this rank. In the following pages most of these families are discussed under the head of the orders in which they have been most commonly placed; in each case, however, the possible rank of the group as a distinct order is indicated.

There is one more proposed modification of the Linnæan system which should be noticed in this place. Nearly all of the families in the orders Pseudoneuroptera and Neuroptera are remarkably distinct. Each family differs from the other families in the same order in much more important characters than usually distinguish families in the other orders. At the same time the characters which distinguish either of these orders are not well marked. For these reasons Professor Brauer holds that the Pseudoneuroptera and the Neuroptera are not natural orders, but that the former group includes four and the latter three distinct orders.

Although in some respects (as, for example, in the classing together of the Termitidæ, Psocidæ, and Mallophaga as an order, the Corrodentia) I cannot follow Professor Brauer, I am inclined to think that in the main the school of entomologists which he represents is in the right as regards the number and characters of the orders of the Hexapoda. And I frankly confess that in adhering so closely to the old classification I have been greatly influenced by a desire to make my presentation of the subject as simple as possible, and by the belief that an elementary text-book should follow rather than lead in matters of this kind. I have, however, endeavored to present the facts in such a manner as to clearly indicate the ideas of the different schools.

On the following page two lists of orders are given. In the first column are indicated the orders recognized in this work; in the second column are indicated the various other orders that have been proposed. The reasons in each case for considering these smaller groups orders is given later, under the special discussion of the group.

LISTS OF ORDERS OF HEXAPODA.

I.	II.
I. THYSANURA.	THYSANURA.
II. PSEUDONEUROPTERA.	PLECTOPTERA. (*Ephemeridæ.*) ODONATA. (*Libellulidæ.*) PLECOPTERA. (*Perlidæ.*) CORRODENTIA. (*Mallophaga, Psocidæ, Termitidæ.*)

I.	II.
III. Orthoptera.	Dermaptera. (*Forficulidæ.*) Orthoptera.
IV. Physopoda.	Physopoda.
V. Hemiptera.	Homoptera. Heteroptera.
VI. Neuroptera.	Neuroptera. (*Sialidæ, Hemerobidæ.*) Mecaptera. (*Panorpidæ.*) Trichoptera. (*Phryganeidæ.*)
VII. Lepidoptera.	Lepidoptera.
VIII. Diptera.	Diptera. Siphonaptera. (*Pulicidæ.*)
IX. Coleoptera.	Strepsiptera. (*Stylopidæ.*) Achreioptera. (*Platypsyllidæ.*) Coleoptera.
X. Hymenoptera.	Hymenoptera.

It is not my purpose in this place to discuss the distinguishing features of the orders of insects. But it seems worth while to present here a brief tabular statement of the more important ordinal characters. This table will aid the student in formulating his ideas as to the characters of the orders and as to the relations of the orders to each other. It should be borne in mind, however, that a linear arrangement is not a natural one; it is simply a necessity of book-making. The arrangement adopted here is the one that I believe best indicates the relative rank of the various orders taken as a whole.

There is no doubt that the Thysanura is the lowest of the orders. But the position assigned to any one of the other orders is open to dispute. Thus we find in the Orthoptera certain forms (the earwigs) which show as strong affinities to the Thysanura as do any of the Pseudoneuroptera. And some entomologists hold that the Physopoda is the lowest of the orders of winged insects.

To enter into a detailed discussion of the reasons which have led me to adopt the sequence of the orders given in the following pages would be beyond the scope of this work; but the following generalizations will indicate the more important ones.

That series of orders in which the insects undergo an incomplete metamorphosis (the *Ametabola*) is undoubtedly lower than that (the *Metabola*) in which the transformation is a complete one. The chief objection to placing the latter series as a whole above the former is the wide separation thus brought about between the Neuroptera and Pseudoneuroptera. I have felt, however, that this was the least of two evils. Within the lower series the two orders in which the mouth-parts are formed for biting are placed lower on this account than the two orders in which the mouth is more highly modified. Of these

two orders of biting insects there can be but little doubt that certain members of the Orthoptera (the crickets and katydids) reach a higher specialization in structure than do any of the Pseudoneuroptera. The Physopoda are undoubtedly lower in structure than the Hemiptera; but they resemble that order more closely than any other in the structure of the mouth-parts. The determination of the proper sequence of the orders of the Metabola is a much more difficult question than that of the Ametabola. Of the five orders which constitute the higher series, entomologists are agreed that the Neuroptera are the lowest in structure. The Hymenoptera are placed highest with almost equal unanimity; not only do these insects exhibit a very high degree of organization, but the development of the instinctive powers reached by bees, wasps, and ants is greater than that attained by any other insects. The Lepidoptera are placed next to the Neuroptera on account of the affinities between the caddice-flies and moths. On the other hand, the higher Lepidoptera and the Diptera resemble each other in the structure of the thorax. And the pupæ of certain Diptera (Cecidomyidæ and Tipulidæ) resemble more or less the pupæ of Lepidoptera. The Coleoptera are assigned to the next highest place, with the belief that their complexity of structure entitles them to this rank; but with no intention of suggesting affinities with the Hymenoptera on the one hand or the Diptera on the other.

Following the tabular statement of the more important characters of the orders of insects, there is given a table to aid the student in classifying specimens. This table is purely artificial and includes only adult insects. I have endeavored, however, to include in it all of the aberrant forms, those which the young student would find difficult to classify.

TABULAR STATEMENT OF THE MORE IMPORTANT CHARACTERS OF THE ORDERS OF HEXAPODA.

A. Wingless insects which show no evidences of having descended from winged ancestors (*i.e.*, in which the thorax is simple in structure), and which undergo no metamorphosis. (*Synaptera.*) I. THYSANURA.

AA. Winged insects; or wingless insects in which this condition is the result of a retrograde development, indicated by the complicated structure of the thorax, or by the presence of wings in closely allied forms. (*Pterygogenea.*)

B. Insects with an incomplete metamorphosis. (*Ametabola.*)

C. Mouth-parts formed for biting; *i.e.*, with the mandibles and maxillæ in the form of jaws.

D. The two pairs of wings similar in structure, membranous. II. PSEUDONEUROPTERA.

DD. The first pair of wings parchment-like; the second pair membranous, and folded in plaits longitudinally. III. ORTHOPTERA.

CC. Mouth-parts intermediate in structure between those of the biting insects and those of the sucking insects: *viz.*, with bristle-like mandibles and with flat, triangular maxillæ. IV. PHYSOPODA.

CCC. Mouth-parts formed for sucking; *viz.*, with the mandibles and maxillæ bristle-like. V. HEMIPTERA.

BB. Insects with a complete metamorphosis. (*Metabola.*)

C. Mouth-parts formed for biting; *viz.*, both mandibles and maxillæ in the form of jaws.

D. The two pairs of wings similar in structure, membranous, with many veins and cells. VI. NEUROPTERA.

DD. The first pair of wings much thickened (horny) throughout their entire length, and meeting in a straight line down the back; the second pair membranous. IX. COLEOPTERA.

CC. Mouth-parts formed for both biting and sucking; *viz.*, with the mandibles in the form of jaws; and with the maxillæ and labium fitted for taking liquid food. Both pairs of wings membranous, with few veins and cells. X. HYMENOPTERA.

CCC. Mouth-parts formed for sucking.

D. With four wings clothed with minute imbricated scales; mandibles rudimentary; maxillæ developed into a sucking tube. VII. LEPIDOPTERA.

DD. With only two wings; the hind wings represented by a pair of knobbed, thread-like organs; mandibles and maxillæ bristle-like. VIII. DIPTERA.

TABLE FOR DETERMINING THE ORDERS OF HEXAPODA.

(This table includes only adult insects.)

A. Wingless or with rudimentary wings.

B. Mandibles and maxillæ retracted within the cavity of the head so that only their apices are visible. I. THYSANURA.

BB. Mandibles and maxillæ more or less prominent and fitted for biting.

C. Head with long, trunk-like beak. (*Boreus.*) VI. NEUROPTERA.

CC. Head not prolonged into a trunk.

D. Louse-like insects of small size; body less than one-sixth inch in length. (*Book-lice and Bird-lice.*) II. PSEUDONEUROPTERA.

DD. Insects of various forms, but not louse-like, and, except in the case of some ants, with the body more than one-sixth inch in length.

E. Abdomen with short, conical, compressed, many-jointed caudal appendages. (*Cockroaches.*) III. ORTHOPTERA.

EE. Abdomen without jointed caudal appendages.

F. Legs fitted for jumping. (*Wingless Locusts, Grasshoppers, and Crickets.*) III. ORTHOPTERA.

FF. Legs fitted for running.

G. Abdomen broadly joined to thorax.

H. Body linear. (*Walking-sticks.*) III. ORTHOPTERA.

HH. Body white and somewhat ant-like in form. (*Termes.*) II. PSEUDONEUROPTERA.

HHH. Body neither linear nor ant-like in form. (*Wingless Fire-fly et al.*) IX. COLEOPTERA.

GG. Base of abdomen strongly constricted. (*Ants et al.*)
X. HYMENOPTERA.

BBB. Mouth-parts formed for sucking.

C. Small abnormal insects in which the body is either scale-like or gall-like in form, or grub-like, and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer, or of a thin scale, beneath which the insect lives. (*Coccidæ.*)
VI. HEMIPTERA.

CC. Body more or less covered with minute scales, or with thick long hairs. Prothorax not free (*i.e.*, closely united with the mesothorax). Mouth-parts usually consisting of a long "tongue" rolled beneath the head. VII. LEPIDOPTERA.

CCC. Body naked, or with isolated or bristle-like hairs.

D. Prothorax not well developed, inconspicuous or invisible from above. Tarsi five-jointed. Mouth-parts developed into an unjointed trunk; palpi present. VIII. DIPTERA.

DD. Prothorax well developed.

E. Body strongly compressed; tarsi five-jointed. (*Fleas.*)
VIII. DIPTERA.

EE. Body not compressed; tarsi one-, two-, or three-jointed.

F. Last joint of tarsi bladder-like or hoof-like in form and without claws; mouth-parts forming a triangular, unjointed beak; palpi present. IV. PHYSOPODA.

FF. Last joint of tarsi not bladder-like, and furnished with one or two claws; mouth-parts forming a slender, usually jointed beak; palpi wanting. V. HEMIPTERA.

AA. Winged.

B. With two wings.

C. First pair of wings transformed into club-shaped appendages. (*Stylopidæ.*) IX. COLEOPTERA.

CC. Second pair of wings rudimentary or wanting.

D. Wings horny, leathery, or parchment-like.

E. Mouth-parts formed for sucking. Wings leathery, shortened, or membranous at the tip. V. HEMIPTERA.

EE. Mouth-parts formed for biting. Jaws distinct.

F. Wings horny, without veins. Hind legs not fitted for jumping.
IX. COLEOPTERA.

FF. Wings parchment-like, with a network of veins. Hind legs fitted for jumping. III. ORTHOPTERA.

DD. Wings membranous.

E. Abdomen with caudal filaments. Mouth-parts rudimentary.

F. Halteres wanting. (*Cloëon and Cœnis, in Ephemeridæ.*)
IV. PSEUDONEUROPTERA.

FF. Halteres present (males of Coccidæ). V. HEMIPTERA.

EE. Abdomen without caudal filaments. Halteres in place of second wings. Mouth-parts formed for sucking. VIII. DIPTERA.

BB. With four wings.

C. The two pairs of wings unlike in structure. Prothorax freely movable.

D. Front wings leathery at base, and membranous at tip, often overlapping. Mouth-parts formed for sucking. V. HEMIPTERA.

DD. Front wings of same texture throughout.

E. Front wings horny or leathery, forming veinless wing-covers. (*Elytra.*)

F. Abdomen with caudal appendages in the form of movable forceps. (*Earwigs.*) III. ORTHOPTERA.

FF. Abdomen without forcep-like appendages. IX. COLEOPTERA.

EE. Front wings leathery or parchment-like, with a network of veins.

F. Under wings not folded. Mouth-parts formed for sucking. V. HEMIPTERA.

FF. Under wings folded lengthwise. Mouth-parts formed for biting. III. ORTHOPTERA.

CC. The two pairs of wings similar, membranous.

D. Last joint of tarsi bladder-like or hoof-like in form and without claws. IV. PHYSOPODA.

DD. Last joint of tarsi not bladder-like.

E. Wings entirely or for the greater part clothed with scales. Mouth-parts formed for sucking. VII. LEPIDOPTERA.

EE. Wings naked, transparent, or thinly clothed with hairs.

F. Mouth-parts arising from the hinder part of the lower surface of the head, and consisting of bristle-like organs enclosed in a jointed sheath. (*Homoptera.*) V. HEMIPTERA.

FF. Mouth-parts in normal position. Mandibles not bristle-like.

G. Wings net-veined, with many veins and cross-veins.

H. Tarsi consisting of less than five segments. II. PSEUDONEUROPTERA.

HH. Tarsi consisting of five segments.

I. Abdomen with setiform, many-jointed anal filaments. (*Certain May-flies.*) II. PSEUDONEUROPTERA.

II. Abdomen without many-jointed anal filaments. VI. NEUROPTERA.

GG. Wings with branching veins and comparatively few cross-veins, or veinless.

H. Tarsi two- or three-jointed.

I. Posterior wings smaller than the anterior. (*Psocidæ.*) II. PSEUDONEUROPTERA.

II. Posterior wings as large or larger than the anterior ones. (*Certain Stone-flies.*) II. PSEUDONEUROPTERA.

HH. Tarsi four- or five-jointed.

I. Abdomen with setiform, many-jointed anal filaments. (*Certain May-flies.*) II. PSEUDONEUROPTERA.

II. Abdomen without many-jointed anal filaments.

J. Prothorax horny. First wings larger than the second, naked or imperceptibly hairy. Second wings without or with few, usually simple, veins. Jaws (mandibles) well developed. Palpi small. X. HYMENOPTERA.

JJ. Prothorax membranous or, at the most, parchment-like. Second wings as large as or larger than the first, folded lengthwise, with many branching veins. First wings naked or thinly clothed with hair. Jaws (mandibles) inconspicuous. Palpi long. Moth like insects. (*Phryganeidæ.*) VI. NEUROPTERA.

CHAPTER IV.

Order I.—THYSANURA.*

(*Bristle-tails, Spring-tails, Fish-moths, et al.*)

The members of this order are wingless insects which undergo no metamorphosis, the larval form being retained by the adult. The mandibles and maxillæ are retracted within the cavity of the head, so that only their apices are visible; they have, however, some freedom of motion, and can be used for biting and chewing soft substances. True compound eyes are rarely present; but in some genera there is a group of agglomerated simple eyes on each side of the head. The abdomen is sometimes furnished with rudimentary legs; and in one genus there are well-developed abdominal legs.

This order comprises chiefly minute insects, which live on decaying vegetable matter, and can be found abundantly in damp situations; some species, however, live in warm and dry places, and feed upon starched clothing, the binding of books, and other dry substances. In the more common species, the body is either elongated, and furnished with six well-developed legs, and two or more long, many-jointed, caudal appendages (Fig. 56); or short, thick, and with a forked springing apparatus, bent under the abdomen, instead of the thread-like caudal appendages (Fig. 57).

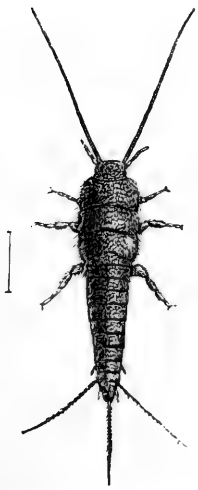

FIG. 56.—*Lepisma saccharina.* (After Lubbock.)

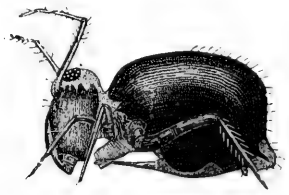

FIG. 57.—*Papirius fuscus.* (After Lubbock.)

* Thysanūra: *thysanos* (θύσανος), a tassel; *oura* (οὐρά), the tail.

Owing to the small size of these insects, the majority of them escape the attention of all except the more careful students of nature. The order is, however, of great interest to entomologists; for it includes the lowest or simplest of the true insects; and in it are found forms which show close affinities to the next lower class, the Myriapoda. It is thus one of the connecting links of which we hear so much in these days; and in it are, doubtless, forms which more closely resemble than any other living species those which in ancient geological times were the first Hexapoda to appear on the earth.

The low rank of these insects is indicated in many ways. The mouth-parts are of a primitive form; wings are never developed; and the insects undergo no metamorphosis, the larval form being retained by the adult.

The absence of wings in this order is believed to represent the primitive condition of these insects. None of the species show any indication of the development of these organs. And the thorax does not present that complication of structure which is the result of the development of wing-muscles. In each of the higher orders we find wingless species; but in these cases there is good reason for believing that the wingless condition is the result of a retrograde development. In some cases this degradation is the result of parasitic habits, as with lice, fleas, and mady other parasites; in other instances it is the result of the separation of the species into several castes, of which some do not require wings, as the workers and soldiers among Termes, and the sedentary generations of the Aphides.

Upon the distinction given above Professor Brauer separates the insects into two classes. The first includes only the Thysanura; this he calls the *Apterygogĕnea*, or "originally wingless insects;" it coincides with the super-order *Synăptera* of Packard. The second class Brauer terms the *Pterygogĕnea*, or "originally winged insects."

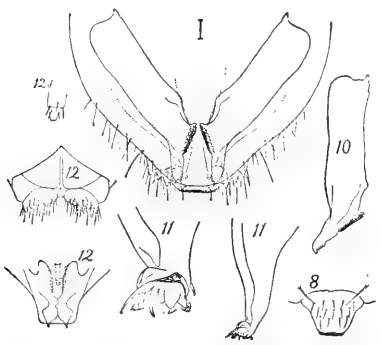

FIG. 58.—Mouth-parts of a Spring-tail, *Entomobryidæ*. (Drawn by J. M. Stedman, under the author's direction.) 8, labrum; 10, mandible; 11, maxilla; 12, labium; 12*d*, labial palpus.

The form of the mouth-parts of the Thysanura is very different from that seen elsewhere in the class Hexapoda. Here the mandibles and maxillæ, although fitted for biting, are retracted within the head, instead of being attached externally as is the case with the higher insects whose mouth-parts are formed for biting. Fig. 58, I, shows the relation of the jaws to the wall of the head in a common spring-tail, one of the *Entomobryidæ*. In this

figure the mandibles are represented by a continuous line, and the maxillæ by a dotted one. It will be observed that only the tips of these organs project from the cavity of the head.

There are, as pointed out by Meinert and by Lubbock, among the Hexapods three principal forms of mouth:

"First, the mandibulate, in which the mandibles and maxillæ are attached externally, and are more or less powerful and adapted for biting and chewing.

"Second, the suctorial, in which the mandibles and maxillæ are attached internally, and are not opposite, but parallel, and intended for pricking.

"Third, the type presented by the Thysanura, in which the mandibles and maxillæ are attached internally, and are far from strong, but still have some freedom of motion, and can be used for biting and chewing soft substances.

The Thysanura includes three sub-orders; these can be separated by the following table:

A. With well-developed abdominal legs, insect resembling a Myriapod in form. I. SYMPHYLA.

AA. With only six well-developed legs.

B. Without ventral abdominal sucker. Caudal appendages bristle-like and many-jointed, or in the form of a pair of forceps. II. CINURA.

BB. With a bifurcated sucker or tubercle on the ventral aspect of the first abdominal segment. Abdomen with a springing apparatus, or without appendages. III. COLLEMBOLA.

Sub-Order I.—SYMPHYLA.*

This sub-order has been erected for the reception of a single genus, *Scolopendrella*. This genus includes certain minute insects the zoological position of which is in doubt. All of the known species are less than 7 mm. (.28 in.) in length. The general form of the body resembles that of a Centipede; and as with the centipedes, each abdominal segment bears a pair of legs. But except in the presence of these abdominal legs the structure of the body is more like that of the Cinura than that of the Myriapods. And the legs are five-jointed and end in two claws as in the Cinura; while in the Myriapoda there are six joints, and always a single large claw.

Sub-Order II.—CINURA.†

(*Bristle-tails and Fish-moths.*)

Among the pests that annoy the housekeeper there is one which is wingless, but can run rapidly, and which has long thread-like ap-

* Symphȳla: *syn* (σύν), together; *phyla* (φυλή), tribe.

† Cinūra: *cineo* (κινέω), to move; *oura* (ουρά), a tail.

pendages at the caudal end of its body. This insect, on account of the minute, shining scales with which its body is clothed, is known as the fish-moth. And it is the most familiar representative of the sub-order Cinura. Other species occur beneath the bark of decaying trees and in similar situations. The caudal end of the abdomen is usually furnished with slender bristle-like appendages. These suggest the popular name Bristle-tails applied to the sub-order as a whole.

The body consists of the head, three thoracic and ten well-marked abdominal segments. The antennæ are large, many-jointed, sometimes longer than the body, and generally tapering towards the end.

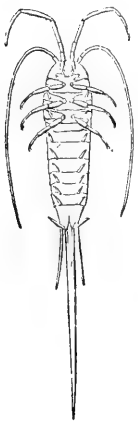

FIG. 59.—Ventral aspect of *Machilis*, showing appendages.

The most remarkable character presented by this order is a series of sub-abdominal appendages. These are well shown in *Machilis* (see Fig. 59). Similar appendages are attached to the coxæ of the second and third pairs of thoracic legs. These abdominal appendages are regarded as rudimentary legs. We have here, therefore, a condition approaching that exhibited by Scolopendrella.

The Cinura (Thysanura of Lubbock) is divided into three families. These can be distinguished as follows:

A. Body not clothed with scales.
  B. Caudal appendages unsegmented, horny and pincer-like.
    I. JAPYGIDÆ.
  BB. Caudal appendages many-jointed and thread-like.
    II. CAMPODEIDÆ.
AA. Body clothed with scales.
    III. LEPISMIDÆ.

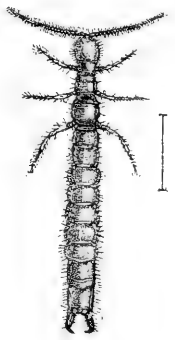

FIG. 60.—*Japyx solifugus*. (After Lubbock.)

Family I. JAPŸGIDÆ.—The most obvious character of this family is presented by the caudal appendages. These resemble those of earwigs, being in the form of horny forceps. The body is not clothed with scales; eyes are wanting. The palpi are short; and the segments of the abdomen are of nearly equal width. The sub-abdominal appendages are represented by groups of hairs.

Only a single genus, *Jāpyx*, has been described. *Jāpyx subterrāneus* "is found under stones at the mouth of a small grotto near the Mammoth Cave."

Family II. CAMPODĒIDÆ.—This family resembles the preced-

ing in that the body is not clothed with scales, the eyes are wanting, and the segments of the abdomen are of nearly equal width. But the caudal appendages are long, thread-like, and many-jointed. To each of the first seven abdominal segments there is attached a pair of ventral appendages, the rudimentary legs already mentioned.

FIG. 61. — *Campodea staphylinus.* (After Lubbock.)

Two genera have been described. *Campōdea* has two caudal appendages, and the palpi are minute. In *Nicoletīna* there are three caudal appendages, and the palpi are long.

Family III. LEPISMIDÆ.—In this family the body is clothed with scales; the palpi are short; and the abdomen tapers towards the caudal end. The eyes are large, compound, and contiguous in *Măchilis;* and small and far apart in *Lepĭsma.* The sub-abdominal appendages are well developed in *Machilis;* in *Lepĭsma* they are confined to two of the posterior segments, and represented by groups of stiff hairs on the anterior ones. The three described genera are distinguished as follows:

FIG. 62. — *Lepisma saccharina.* (After Lubbock.)

A. Prothorax much enlarged, and the abdomen tapering rapidly, so that the body is almost heart-shaped; caudal appendages short. LEPISMINA.

AA. Body more elongated; caudal appendages long.

B. Eyes large and contiguous. MACHILIS.

BB. Eyes small and far apart. LEPISMA.

The Fish-moth, *Lepĭsma saccharina* (Fig. 62), is a well-known pest in some parts of the country. It is silvery white with a yellowish tinge about the antennæ and legs; it measures 8 mm. (.31 in.) in length. It injures clothing, especially starched clothes; and the bindings of books. An instance was reported to me where they caused the paper to cleave from the walls of a house by feeding upon the starch with which it was fastened in place.

Sub-Order I.—COLLEMBOLA.*

(*Spring-tails.*)

To this sub-order belong certain minute insects which have received the common name Spring-tails. They are often of microscopic size. The majority live on decaying matter; and are very common under stones and decayed leaves and wood, in the chinks and crevices of bark, among moss, and on herbage in damp places. Sometimes they occur abundantly in winter on the surface of snow; where they appear as minute black specks, which spring away on either side from our feet as we walk. And some species collect in great numbers on the surface of standing water.

The body consists of the head, three thoracic and six abdominal segments. The abdominal segments are not well marked in some forms. No compound eyes exist in this sub-order. There is, however, usually a group of simple eyes on each side of the head. The antennæ consist of but few, four to eight, segments. The mouth-parts are formed for biting, except in *Anoura*, where the mandibles and maxillæ are wanting.

The name Collembola refers to a curious organ situated on the ventral aspect of the first abdominal segment, the ventral tube or sucker. "In *Podura*, *Lipura*, and the allied genera, this organ is a simple tubercle; divided into two halves by a central slit; in other genera, as, for instance, in *Orchesella* and *Tomocerus*, the tubercle is enlarged, and becomes a tube divided at the free end into two lobes. In the Smynthuridæ and Papiriidæ the organ receives a still further and remarkable development; from the end of the tube the animal can project two long, delicate tubes provided at their extremity with two glands." (Lubbock.) By means of this sucker and the fluid excreted by its glands these insects are enabled to cling to the lower surface of smooth objects.

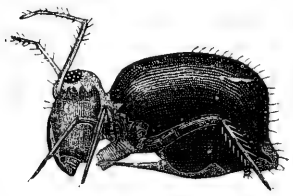

FIG. 63.—*Papirius fuscus*. (After Lubbock.)

The popular name Spring-tails was suggested for these insects by a peculiar leaping apparatus which most of them possess. It consists of a long appendage of either the fourth or fifth abdominal segment, which extends under the abdomen towards the head.

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* Collĕmbola: *colon* (κωλον), a limb; *embole* (εμβολή), a throwing.

This appendage consists of a basal segment and two appendages; which are sometimes two-jointed, and sometimes consist of a single piece each. This appendage constitutes the spring. On the ventral side of the third abdominal segment in certain genera is also an appendage, which is termed the catch. This catch passes between the branches of the spring and holds it in place. By relieving the spring and extending it suddenly the insect is able to throw itself to a considerable distance.

Some of the Collembola are clothed with scales, resembling in this respect butterflies and moths. These scales are very minute, and wonderfully sculptured. The markings on them are so minute that it requires a very good microscope to resolve them. On this account they have been much used as test objects for microscopes under the name of "Podura scales."

The most remarkable feature in the structure of the Collembola is that in nearly the entire sub-order tracheæ are wanting; while in certain members, *Smynthrus*, there is a well-developed respiratory system. The difference is a great one to exist between genera otherwise so closely allied.

In certain respects the Collembola is the lowest of the three sub-orders of the Thysanura; and it is so placed in some of the standard works on entomology. The mouth-parts are very rudimentary in this sub-order; and the tracheæ are rarely developed. But it has seemed more natural to me to follow the Myriapoda by Scolopendrilla; and to place next the sub-order Cinura, containing, as it does, forms with rudimentary abdominal legs. We have thus an unbroken series from the Myriapodous to the Hexapodous condition. In the Collembola we have insects which, while retaining a very primitive form of the mouth-parts and of the respiratory system (the result of their continuing to feed on soft substances, and to live in damp situations), present a much modified form of the body, and the development of peculiar special organs, the spring and the ventral tube or sucker. We thus see well illustrated the difficulties, referred to elsewhere, of any attempt to arrange animals in a linear series.

The Collembola is divided by Lubbock into six families. These can be separated by the following table:

A. Saltatorial.
  B. Body globular.
    C. Terminal segment of abdomen short, with whorls of hair. 1. PAPIRIIDÆ.
    CC. Terminal segment long, ringed. 2. SMYNTHURIDÆ.
  BB. Body cylindrical.

C. The spring an appendage of the penultimate (fifth) abdominal segment. 3. ENTOMOBRYIDÆ.*
CC. The spring an appendage of the antipenultimate (fourth) abdominal segment. 4. PODURIDÆ.
AA. Non-saltatorial.
B. Mouth mandibulate. 5. LIPURIDÆ.
BB. Mouth suctorial. 6. ANOURIDÆ.

Family I. PAPIRĪIDÆ.—Two genera of this family have been established. *Papirius* is characterized by four-jointed antennæ; and *Dicyrtoma* by having the antennæ eight-jointed. A large species from Maine and Massachusetts, measuring $2\frac{1}{2}$ mm. (0.1 in.) in length, is described by Packard under the name *Papĭrius marmorātus*. It is marbled with deep dull lilac and pearl-colored lines and spots.

Family II. SMYNTHŪRIDÆ.—Only a single genus of this family, Smynthurus, has been described. In this genus the antennæ are four-jointed, and the respiratory system is well developed. The presence of tracheæ enable these insects to live in drier situations than can other members of the sub-order. The Garden Flea, *Smynthurus hortensis*, is described by Fitch as occurring abundantly in May and June, upon the leaves of young cabbage, turnip, cucumber, and various other plants, and also on the ground. It is dull black, with the head, legs, and bases of the antennæ rust-color. Several other species of this genus have been described by Fitch and Packard.

Family III. ENTOMOBRŸIDÆ.—This is by far the largest family in this order; nine genera having been described. These can be separated by the following table, which is from one given by Lubbock:

A. Antennæ six-jointed. ORCHESĔLLA.
AA. Antennæ four- or five-jointed.
B. With scales.
C. Terminal segments of antennæ ringed.
D. Two terminal segments ringed.
E. Eyes seven in each group. TOMŎCERUS.
E. Eyes absent. TRITOMŪRUS.
D. Third segment simple. TEMPLETŌNIA.
CC. Terminal segment of antennæ simple.
D. No eyes. BĔCKIA.
DD. With eyes.
E. Head exposed. SĒĪRA.

* The Degeeriadæ of Lubbock. The generic name Degeeria falls owing to its having been previously used in the Diptera.

EE. Head more or less concealed under the thorax. LEPIDOCYRTUS.
BB. Without scales.
C. Abdominal segments unequal. ENTOMŎBRYA.
CC. Abdominal segments subequal. ISŎTOMA.

Family IV. PODŪRIDÆ.—The *Poduridæ* comprises two genera, *Achorutes*, in which the tarsi have two claws, and *Podura*, in which there is but a single claw on each tarsus. Certain species of each genus are found on the surface of standing water. Our common "Snow-flea" is *Achorutes nivicola*. This is sometimes a pest where maple-sugar is made; the insects collecting in large quantities in the sap.

Family V. LIPŪRIDÆ.—The body is cylindrical in form; there is no saltatorial appendage; and the mouth-parts are formed for biting. Only a single genus, *Lipura*, has been described.

Family VI. ANOŪRIDÆ.—This family resembles the preceding in the cylindrical form of the body, and in the absence of a saltatorial appendage; but it differs from all other members of the Thysanura, in having the mouth-parts formed for sucking. The mouth-parts are exceedingly rudimentary; there being neither mandibles nor maxillæ. There is but a single genus, *Anoura*, known. The name of this genus will doubtless be changed, as it is preoccupied by a genus of bats.

CHAPTER V.

Order VI.—PSEUDONEUROPTERA.*

(*Dragon-flies, May-flies, Stone-flies, et al.*)

The members of this order have four wings; these are membranous, and usually furnished with numerous veins. The mouth-parts are formed for biting except in one family (Ephemeridæ), where they are rudimentary. The metamorphosis is incomplete.

The insects which are here classed as the order Pseudoneuroptera, and those which in a later part of the book are termed Neuroptera were formerly united in a single order, under the name Neuroptera. This union was based upon the similarity of the characters presented by the mouth-parts and the wings in the two groups. But there is a radical difference in the nature of the transformations. In one the metamorphosis is incomplete; in the other it is complete. Although it is difficult to find characters presented by the adult insects which will separate these two groups, this difference in the transformations indicates that they are not closely enough related to be placed in the same order. The term Neuroptera has, therefore, been restricted to those with a complete metamorphosis; and the name Pseudoneuroptera, *i.e.*, false Neuroptera, applied to those with an incomplete metamorphosis.

The beginning student, in the classification of his specimens, will find some difficulty in separating these two orders. But this can be done by means of the table on pages 49 to 52. And as soon as one becomes familiar with the families included in these orders there will be no necessity for the use of the table.

In the linear arrangement I have adopted, these two closely-allied orders become widely separated; this results from the separation of the orders into two series, in one of which the metamorphosis is incomplete, in the other complete.

The Pseudoneuroptera is not a well-marked order. Not only is it difficult to distinguish it from the Neuroptera, but it includes families which differ greatly from each other. The differences be-

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* Pseudoneurŏptera: *pseudes* (ψευδής), false; Neuroptera.

tween the families are much greater than is usual between the families of the same order. On this account it is proposed by Professor Brauer to break the Pseudoneuroptera up into at least four orders, one for each of the first three families, and one for the last three. It remains to be seen whether this multiplication of the orders will be accepted by entomologists generally.

Owing to the great differences which exist between the families of the Pseudoneuroptera, I will not attempt to make further generalizations respecting the group in this place.

The Pseudoneuroptera is represented in this country by six families. These can be separated by the following table:

TABLE OF FAMILIES OF PSEUDONEUROPTERA.*

A. With four or two well-developed wings.
  B. Antennæ inconspicuous, awl-shaped, short and slender.
    C. First and second pair of wings nearly of the same length; tarsi three-jointed. 2. LIBELLULIDÆ.
    CC. Second pair of wings either smaller or wanting; tarsi four- or five-jointed. 1. EPHEMERIDÆ.
  BB. Antennæ usually conspicuous, setiform, filiform, clavate, capitate, or pectinate.
    C. Tarsi two- or three-jointed.
      D. Second pair of wings the smaller. 5. PSOCIDÆ.
      DD. Second pair of wings broader, or at least of the same size as the first pair. 3. PERLIDÆ.
    CC. Tarsi four-jointed; wings equal. 6. TERMITIDÆ.
AA. Wingless, or with rudimentary wings.
  B. Tarsi four-jointed. 6. TERMITIDÆ.
  BB. Tarsi three-jointed.
    C. Wingless, or with two rudimentary wings of a leathery substance. 5. PSOCIDÆ.
    CC. Four rudimentary wings, still with distinct venation. 3. PERLIDÆ.
  BBB. Tarsi two- or one-jointed. 4. MALLOPHAGIDÆ.

Family I.—EPHEMERIDÆ.†

Order PLECTOPTERA of some authors.‡

(*May-flies.*)

The May-flies or Ephemerids are often very common insects in the vicinity of streams, ponds, and lakes; frequently the surface of such bodies of water is thickly strewn with them. They are attracted by

* After Baron Osten Sacken, in Hagen's Synopsis.

† Ephemĕridæ, Ephĕmera: *ephemeron* (ἐφήμερον), a may-fly.

‡ Plectoptera; *plectos* (πλεκτός), plaited; *pteron* (πτερόν), a wing.

lights; and it is not an uncommon occurrence in summer-time to see hundreds of them flying about a single street-lamp.

Fig. 64.—May-fly.

They are very fragile insects, with large delicate fore wings, with the hind wings much smaller or wanting, and with the abdomen furnished at its caudal end with either two or three many-jointed, thread-like appendages (Figs. 64 and 64*a*).

The body is smooth, not

Fig. 64*a*.—*Cænis*.

clothed with scales or hairs. The head is free, with atrophied mouth-parts, and inconspicuous antennæ. These are composed of two short stout segments succeeded by a slender many-jointed bristle. The thorax is robust, with the mesothorax predominant. The great development of this segment is correlated with the large size of the fore wings. The abdomen is long, soft, and composed of ten segments. In the male there is a pair of clasping organs placed ventrally at the extremity of the ninth segment; these are usually two-, three-, or four-jointed, and are termed the forceps-limbs. Just behind the forceps-limbs are the paired external sexual organs. The form of the external parts of the reproductive organs is remarkable; each vas deferens and each oviduct has a separate opening. In the male these openings are between the ninth and tenth abdominal segments, as indicated above; in the female, between the seventh and eighth.

The May-flies have received considerable attention in popular writings on account of their ephemeral existence in the adult state. All have read of the insects that live but a day. Reference is made in these accounts to members of this family; and although the popular idea is fallacious, it has some foundation in fact. Strictly speaking, the May-flies are long-lived insects; some species appear twice annually, once in the spring, and again in the autumn; but as a rule one, two, or even three years are required for the development of a

generation. The greater part of this time is passed, however, beneath the surface of water; and after the insect emerges into the air and assumes the adult form its existence is very brief. With many species the individuals leave the water, undergo two transformations, mate, lay their eggs, and die in the course of an evening or early morning. And although the adults of many genera live several days, the existence of these insects is very short compared with members of other families.

The females lay their eggs in water. Some short-lived species discharge the contents of each ovary in a mass. Specimens are often found in which there project from the caudal end of the body two parallel subcylindrical masses of eggs, one protruding from each of the openings of the oviducts. Egg-clusters of this kind "laid upon the water rapidly disintergrate, so as to let the eggs sink broad-cast upon the river-bed. The less perishable species extrude their eggs gradually, part at a time, and deposit them in one or the other of the following manners: either the mother alights upon the water at intervals to wash off the eggs that have issued from the mouths of the oviducts during her flight; or else she creeps down into the water—enclosed within a film of air, with her wings collapsed so as to overlie the abdomen in the form of an acute narrowly linear bundle, and with her setæ closed together—to lay her eggs upon the under side of stones, disposing them in rounded patches, in a single layer evenly spread, and in mutual contiguity." (EATON.)

With most May-flies the general form of the body in the immature stages resembles somewhat that of the adult. The newly-hatched nymphs respire through the integument at large. During the first few days after their birth the young cast their skin several times, the intervals between the moultings lengthening by degrees. Rudiments of tracheal gills begin to appear when the insect is eight or ten days old; they bud forth from the hinder lateral angles of some or all of the first seven abdominal segments; and, like the parts of the mouth, are modified considerably in detail before they acquire their ultimate shapes. They may be either thread-like, tufted, or plate-like in form. In *Oligoneura* and *Jolia* there is a pair of tracheal gills attached to the base of the maxillæ. This is a striking exception to the general rule that external organs of respiration do not appear on the head of insects. Fig. 65 represents a nymph of a May-

FIG. 65.—Nymph of May-fly.

fly, a common representative of this family found under stones in the beds of streams at Ithaca.

"May-fly nymphs mostly feed upon either mud or minute aquatic vegetation, such as covered stones and the larger plants; but (judging by their mandibles and maxillæ) some must be predaceous. Many of them live in concealment in the banks or under stones in the bed of streams, rivers, and lakes; others ramble openly amongst water-weeds and swim with celerity." (EATON.) The nymphs of May-flies undergo many moults; *Cloëon*, according to the observations of Lubbock, sheds its skin twenty-one times. In this insects there are no traces of wings until the ninth state; then the hinder lateral angles of dorsal aspect of the meso- and metathorax become slightly produced. With each successive moult these prolongations become more marked, until in the twentieth state, the last passed under water, the rudimentary wings cover half or the whole of the third abdominal segment. The wing-cases are not inverted (see page 6).

Most members of this family exhibit a remarkable peculiarity in their development. After the insect leaves the water and has apparently assumed the adult form, that is, after direct respiration through the spiracles has been established, and the wings have become fully expanded, it moults again. This is the only instance in which insects with fully developed wings cast their skin. The term subimago is applied to this stage between the nymph and the final form of the insect. With some species the duration of the subimago stage is only a few minutes; the insect moults on leaving the water; flies a short distance; and moults again. In others this stage lasts twenty-four hours or more.

The adults of the Ephemeridæ eat nothing. Not only is the period of existence in this state so brief that food in addition to that taken in the nymph state is unnecessary, but the imperfect condition of the mouth precludes the taking of nourishment. With many species of May-flies there is great uniformity in the date of maturing of the individuals. Thus immense swarms of them will leave the water at about the same time, and in the course of a few days pass away; this being the only appearance of the species until another generation has been developed. The great swarms of "Lake-flies" (*Ephĕmera sĭmulans*), which appear along our northern lakes about the third week in July, afford good illustrations of this peculiarity. And an instance is on record where May-flies thronged to the gas-burners in a store and actually quenched the flames.

The Ephemeridæ are regarded as the lowest living representatives

of one of the lines of development of winged insects. This position is indicated by fan-like form of the wings, which is characteristic of the primordial insects, and by the paired openings of the reproductive organs, a feature not found in highly developed animals.

Our representatives of this family have not been thoroughly studied. Eaton in his monograph* enumerates less than one hundred species from the whole of North America. But these he distributes among more than twenty genera. The following key is based on the characters given for the genera and groups of genera by this author. It will aid the student in classifying his specimens; but it should be regarded as merely provisional.

In distinguishing subordinate groups in the Ephemeridæ much use is made of the venation of the wings. It is necessary here to describe only that of the fore wings. The system adopted is that of Eaton.

The principal nerves of the fore wing show a tendency to be segregated into three groups, as follows: (Fig. 66.)

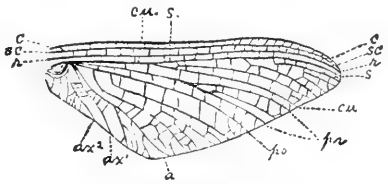

FIG. 66.—Fore wing of May-fly.

Group I.—This group consists of three veins, which communicate directly with the thorax. These are named the *cŏsta* (*c*), *subcŏsta* (*sc*), and *rādius* (*r*). The costa is coincident with the anterior margin of the wing; and the subcosta and radius are nearly parallel with it; the three veins are united near the base of the wing by the great cross vein.

Group II.—This group also consists of three principal veins; but the first of these gives off a prominent branch before the middle of the wing, which is termed the *sĕctor* (*s*). The sector is a branch of the *cŭbitus* (*cu*); just behind the cubitus is the *præbrāchial* (*pr*), and behind that the *postbrāchial* (*po*). This group of veins is annexed to the first group, or terminates in the wing membrane adjacent to it, close to the base of the wing.

Group III.—The remaining veins constitute the third group. This is associated with the prominent curved or angulated crease in the membrane of the wing, which forms the boundary of a depression near the base of the wing. The first vein of this group is the *anal* (*a*); the remaining ones are termed the *ăxillary veins* (ax^1, ax^2, ax^3, etc). The anal vein as a rule subtends directly the anal angle of the wing; in one group of genera it is joined at its base to the postbrachial vein.

* A Revisional Monograph of Recent Ephemeridæ or May-flies, by the Rev. A. E. Eaton. This work is to form Volume III. of the Trans. of the Linn. Soc. of London. Only four parts have appeared at the present writing.

TABLE OF GENERA OF THE EPHEMERIDÆ OF THE UNITED STATES.

A. At the base of the fore wing the anal vein (*a*) meets the postbrachial (*po*); hind tarsi, when not atrophied, have four distinct joints.

B. Female with the hind legs longer than the other pairs; male with the forceps-limbs sessile upon the border of the segment.

C. Includes males only. Two caudal setæ in both genera.

D. Hinder lateral angles of the 9th abdominal segment produced into a short, tooth-like spine. JŌLIA.

DD. Hinder lateral angles of the abdominal segments subrectangular. POLYMITĂRCYS.

CC. Includes females only.

D. Two caudal setæ. JŌLIA.

DD. Three caudal setæ. POLYMITĂRCYS.

BB. Fore legs of females at least as long as hind legs; male with the forceps-limbs inserted at the sides of the terminal border of a short transverse laminar lobe prolonged from the segment.

C. Includes males only.

D. Median seta extremely rudimentary.

E. Fore leg nearly as long as body; the tibia about $1\frac{1}{3}$ as long as femur. Segments of caudal setæ well marked. External sexual organs strongly hooked. HEXAGĒNIA.

EE. Fore leg about half as long as body; tibia about $1\frac{3}{5}$ as long as femur. Segments of caudal setæ inconspicuous. External sexual organs nearly straight. PENTAGĒNIA.

DD. Median seta about as long as the others. EPHĔMERA.

CC. Includes females only.

D. Median seta extremely rudimentary. HEXAGĒNIA.

DD. Median seta about as long as the others.

E. Abdominal segments 6–10 together constituting about $\frac{2}{3}$ of the abdomen; segments of the caudal setæ well marked. EPHĔMERA.

EE. Abdominal segments 6–10 together constituting $\frac{1}{2}$ of the abdomen; segments of the caudal setæ inconspicuous. PENTAGĒNIA.

AA. Anal vein (*a*) of fore wing does not directly meet the postbrachial vein (*po*), but is connected with it by a more or less distinct channel of circulation in the membrane.

B. The channel of circulation connecting postbrachial and anal veins obsolete (except in *Cænis*, a two-winged genus). Hind tarsi with four distinct joints.

C. Hind wings well developed; with a sharply defined, almost right-angled projection situated at about the first $\frac{1}{3}$ of the costal margin. POTAMĂNTHUS.

CC. Hind wings of small or moderate proportions.

D. Hind wings either gently and on the whole continuously curved in front, or else suddenly retracted in the middle of the fore margin.

E. Hind tibia usually longer than the femur, rarely subequal to it.

F. Hind wings in front somewhat depressed in the middle.
G. Median caudal seta subequal to the others. LEPTOPHLĒBIA.
GG. Median caudal seta far shorter than the others. BLASTŪRUS.
FF. Hind wing strongly angulated in front.
G. Basal joint of forceps-limb about as long as the remainder; female with ventral lobe of segment 9 bifid and excised. HABROPHLĒBIA.
GG. Basal joint of foreceps-limb very short; joint 2 longer than the remainder; female with ventral lobe of segment 9 obtuse. CHOROTÉRPES.
E. Hind tibia rather shorter than the femur. EPHEMERĔLLA.
DD. Costal border of hind wings spurred or protuberant at about the first ⅓ of the wing's length.
E. Hind wings small, and extremely narrow; costal projection usually very slender. CENTRŎPTILUM.
EE. Hind wings broad, oblong, and obtuse.
F. Hind wings with numerous cross-veins; costal projection large and rounded. CALLIBÆTIS.
FF. Hind-wings with but few or no cross-veins; costal projection small and acute or wanting. BÆTIS.
CCC. Hind wings wanting.
D. With two caudal setæ. CLŒON.
DD. With three caudal setæ. (Fig. 64*a*.) CÆNIS.
BB. Channel of circulation connecting nerves 8 and 7 well defined; hind tarsi with five distinct joints.
C. Space between anal (*a*) and first axillary (ax^1) veins subtended by the outer half of the inner margin of the wing and the anal angle.
D. Tibiæ of the hind legs longer than, or at least subequal in length to, the tarsi.
E. Proximal joint of the hind tarsus shorter than the second joint.
F. Tarsal claws dissimilar; costal dilatation of the hind wing acute. COLOBŪRUS.
FF. Tarsal claws alike, narrow and hooked; costal dilatation of the hind wing obtuse. CHIROTONĒTES.
E. Proximal joint of the hind tarsus subequal to the second joint; tarsal claws dissimilar; costal dilatation of the hind wing almost right-angled. AMELĒTUS.
DD. Tibiæ of the hind legs shorter than the tarsi; proximal joint of the hind tarsus longer than the second joint. SIPHLŪRUS.
CC. Space between anal (*a*) and first axillary (ax^1) veins subtended entirely by a part of the terminal margin of the wing. BÆTĬSCA.
CCC. Space between anal and first axillary veins subtended by the anal angle and a part of the terminal margin. HEPTAGĒNIA.*

* The American representatives of this genus have been distributed by Eaton among five genera, which are distinguished by such slight and inconstant variations in structure that I have been unable to express them in a tabular form.

Family II.—Libellulidæ.*

Order Odonata† of some authors.

(*Dragon-flies.*)

The Dragon-flies are very common insects in the vicinity of streams, ponds, and lakes. Many of them are of large size; and, as they fly vigorously during the day-time, they are well known. They have consequently received a number of popular names. The most common of these used in this country are Dragon-flies, Darning-needles, Spindles, and Snake-doctors.

The form of members of the Libellulidæ is very characteristic (Fig. 67). The most striking features are the long, spindle-shaped body, and the long, narrow, powerful wings; of which the second pair are as large as or larger than the first pair.

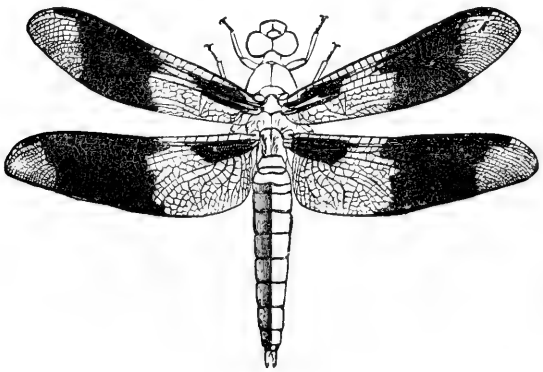

Fig. 67.—*Plathemis trimaculata.* (From Sanborn.)

The head of a dragon-fly is large, broad, often semi-globose, and concave behind. A considerable part of its surface is occupied by the enormously developed compound eyes. The antennæ are short; they consist of from five to eight segments; of these the two basal ones are thick, the others form a bristle-like organ. The mouth-parts are well developed. The labrum is prominent; the mandibles and maxillæ are both strongly toothed; and the labium consists of three large lobes, which with the labrum nearly enclose the jaws when at rest. The thorax is large. The wings are, as a rule, of nearly similar size and structure; they are richly netted with veins; and the front border of each is divided into basal and apical parts by what is termed the nodus (*n*, Fig. 71). The veins and cells are much used in classification; the terms applied to them are given in the explanation of Fig. 71. The abdomen is long, slender, and more or less nearly cylindrical; the caudal end is furnished with

* Libellūlidæ, Libellula: *libella*, a water-level, on account of the position of the wings during flight.

† Odonāta: *odous* (ὀδούς), a tooth.

clasping organs. The most remarkable peculiarity of the order is the fact that the copulatory organs of the male are distinct from the opening of the vasa deferentia; the former are situated on the second abdominal segment, the latter on the ninth. Before pairing the male conveys the seminal fluid to a bladder-like cavity on the second abdominal segment; this is done by bending the tip of the abdomen forward. The pairing takes place during flight. The male seizes the neck of the female with his anal clasping organs; the female then curves the end of her abdomen to the organs on the second abdominal segment of the male.

The eggs are laid in water. In some species the female flies back and forth over the surface of the water, sweeping down at intervals to touch it with the tip of her abdomen, and thus wash off one or more eggs into it. In other cases the eggs are laid in a mass. On one occasion, in company with my class, I saw a dragon-fly poising herself in the air a short distance above the point where a water-plant emerged from the water. At frequent intervals the insect descended with a swift curved motion, pushing the end of her abdomen into the water. On examination a large cluster of eggs were found attached to the plant just below the surface. Professor Uhler has observed a dragon-fly alight upon a water-plant, and, pushing the end of her body below the surface of the water, glue a bunch of eggs to the submerged stem or leaf.

The nymphs of dragon-flies (Figs. 68 and 69) pass their lives in

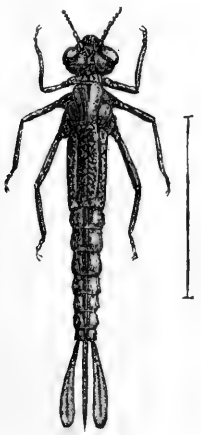

FIG. 68.—Nymph of Dragon-fly, Agrioninæ.

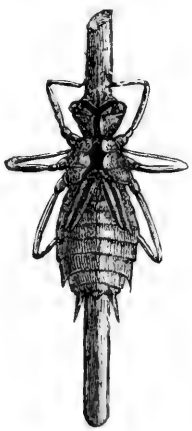

FIG. 69.—Exuviæ of nymph of Dragon-fly.

the water. They are predacious, feeding on such aquatic animals

as they can overcome. The form of the body varies greatly, some species being quite slender, while others are nearly as broad as long. These insects are, however, easily recognized. The general appearance of the body is quite characteristic in spite of the variations in its proportions. There are also certain well-marked structural characters which distinguish the nymphs of dragon-flies from all other insects. The most available of these characters is the form of the mouth-parts. The mouth is furnished with well-developed mandibles and maxillæ, all of which are armed with strong teeth. But none of these is visible when the insect is at rest. The lower lip is greatly enlarged, and so formed that it closes over the jaws concealing them. For this reason it has been termed the mask. But it is much more than a mask; it is a powerful weapon of offence. It is greatly elongated; and is jointed in such a way that it can be thrust out forward in front of the head. It is armed at its extremity with a pair of sharp hooks, adapted for seizing and retaining its prey.

An equally remarkable peculiarity of these insects in their nymph stage is the form of the organs of respiration. The caudal part of the alimentary canal, the rectum, is modified so as to constitute a tracheal gill. It is somewhat enlarged; and its walls are abundantly supplied with tracheæ. Water is alternately taken in and forced out through the anal opening; by this process the air in the tracheæ, with which the walls of the rectum are supplied, is purified in the same manner as in an ordinary tracheal gill.

FIG. 70. — Tracheal gill of nymph of Dragon-fly.

In addition to the rectal tracheal gill, certain dragon-flies possess in their nymph stages other organs of respiration. Thus, in the Agrioninæ there are leaf-like caudal tracheal gills (Figs. 68 and 70); in some of the Calopteryginæ we find lateral abdominal tracheal gills; and in certain forms there are even closing stigmata on the thorax and abdomen.

The rectal tracheal gill of immature dragon-flies is an organ of locomotion, as well as of respiration. By drawing water into the rectum gradually, and expelling it forcibly, the insect is able to dart through the water with considerable rapidity.

When the nymph of a dragon-fly is fully grown it leaves the water to transform. The skin of the nymph splits open on the back of the thorax and head, and the adult emerges, leaving the empty

skin of the nymph clinging to the object upon which the transformation took place. Fig. 69 represents such a skin clinging to the stem of a water-plant.

The dragon-flies are predaceous in the adult as well as in the nymph state; hence their vigorous flight and strong jaws render them formidable foes of less powerful insects.

It is not strange that there should be many popular superstitions regarding insects so conspicuous as these. It is a common belief among children that they have the power of sewing up the ears of people, hence the name darning-needle; while the negroes in the Southern States believe that the dragon-flies hover over dead snakes, bringing them to life, and consequently call them snake-doctors.

The Libellulidæ is a remarkably well-defined group of insects. The wings are peculiar in form and venation, and especially in the possession of the nodus; the reproductive organs of the male are very distinct in form from those of any other insects; and in the nymph the structure of the mouth-parts and the organs of respiration are equally peculiar. Owing to these important differences which exist between the Libellulidæ and the most nearly allied insects, certain entomologists regard the group as an order, to which they apply the name Odonata.

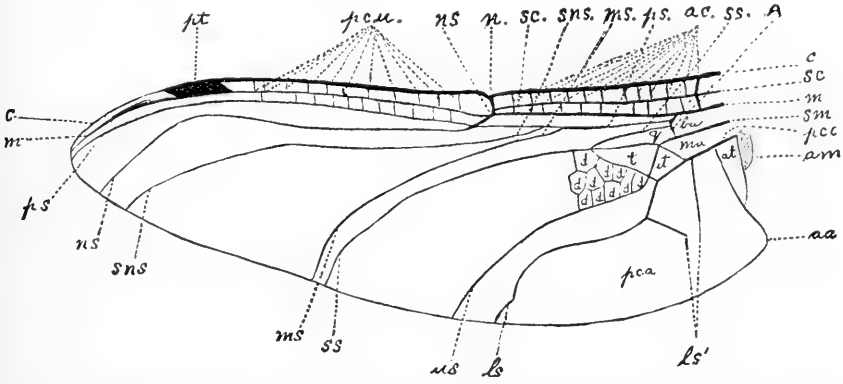

FIG. 71.—Wing of Dragon-fly, *Æschna*. *A*, arc or arculus; *aa*, anal angle; *ac*, antecubital cross-veins; *am*, accessory membrane or membranule; *at*, anal triangle; *ba*, basal area or space; *c*, *c*, costal vein; *d*, *d*, *d*, discoidal areolets; *it*, internal triangle; *ls*, lower sector of triangle, a prolongation of *pco*; *ls'*, branch of *ls*; *m*, *m*, median vein; *ma*, median area or space; *ms*, *ms*, median sector; *n*, nodus; *ns*, nodal sector; *pca*, *pca*, postcostal area; *pco*, postcostal vein, prolonged into *ls*; *pcu*, postcubital cross-veins; *ps*, *ps*, principal sector; *pt*, pterostigma; *q*, quadrangle or area above the triangle; *sc*, *sc*, subcostal vein; *sm*, submedian vein, prolonged into *us*; *sns*, subnodal sector; *ss*, *ss*, short sector; *t*, discoidal triangle, usually termed *the* triangle; *us*, upper sector of the triangle, a prolongation of *sm*.

Figure 71 illustrates the nomenclature of the parts of the wing in insects of this order.

TABLE OF SUB-FAMILIES OF LIBELLULIDÆ.*

A. Wings alike, vertically folded in repose. (Eyes remote and peduncled.)
  B. Antecubital cross-veins numerous, at least five in number. (Wings almost always not petiolated.) 1. CALOPTERYGINÆ.
  BB. Antecubital cross-veins two only. (Wings always distinctly petiolated.) 2. AGRIONINÆ.

AA. Hind wings differently shaped from front wings; all four wings carried horizontally in repose.
  B. Antecubitals of the first and second series not corresponding except at base. Base of second series of postcubitals with cross-veins.
    C. Eyes remote. 4. GOMPHINÆ.
    CC. Eyes touching at a single point, the touching part of each forming an acute angle. 5. CORDULEGASTERINÆ.
    CCC. Eyes touching for a considerable space, the touching part straight, or at a single point (*Æschina heros*), the touching part rounded in a single curve. 3. ÆSCHINÆ.
  BB. Antecubitals of the first and second series corresponding. Base of the second series of postcubitals with no cross-veins.
    C. Each eye laterally tubercled behind. 6. CORDULINÆ.
    CC. Posterior edge of each eye simple. 7. LIBELLULINÆ.

CALOPTERYGINÆ.—There are only two genera of this sub-family represented in our fauna. In *Calŏpteryx* the wings are very broad, and the basal space has no transverse veins. *Hetærīna* differs in having the wings rather narrow, and with the basal space reticulated. In this genus the base of the wings in the male is blood-red.

AGRIONINÆ.—The greater number of our species belong to *Lestes* and *Agrion*. In *Lĕstes* the median and subnodal sectors arise from the principal sector nearer the arculus than the nodus; while in *Ăgrion* these sectors arise under the nodus.

ÆSCHNINÆ.—The greater number of our species belong to the typical genus *Æschna*. In the males of this genus the anal angle of the posterior wings is acute, the lower anal appendage is usually triangular, and the second abdominal segment bears upon each side a little ear-like tubercle. Of the genus *Ānax* we have one common species, *A. jūnius*. This is a large insect, measuring in length 68–74 mm., and having an alar expanse of 104–110 mm. In the males of this genus the anal angle of the posterior wings is rounded like that of the females; the lower anal appendage is short and truncate; and the second abdominal segment has not ear-like appendages.

GOMPHINÆ.—In the typical genus *Gŏmphus* the triangles of all of the wings are without transverse veins; this genus includes many species. In the genera to which the following species pertain the triangles have transverse veins. *Tachŏpteryx thoreyi* is a large insect expanding 100 mm.; it is remarkable for the length of the pterostigma, which measures 9 mm. *Hagĕnius brevistylus* is an even larger species, which expands 104–114 mm. The pterostigma meas-

* After B. D. Walsh, Proc. Ent. Soc. Phil. II. p. 259.

ures only 6 mm., and the tarsi are very long. These two species are our most common representatives of this division of the Gomphinæ.

CORDULEGASTERINÆ.—Our only genus is *Cordulegăster*, of which but few species are found in the United States.

CORDULINÆ.—We have three genera of this sub-family, each of which is well represented in our fauna. These are *Macŏrmia*, *Epithĕca*, and *Cordūlia*.

LIBELLULINÆ.—This sub-family is represented in our fauna by at least ten genera.

Family III.—PERLIDÆ.*

Order PLECOPTERA of some authors.†

(Stone-flies.)

The family *Pĕrlidæ* includes comparatively few species; but members of it are common about any of our creeks. These insects are called Stone-flies because the immature forms are very abundant under stones in the bed of streams. The adults are found flying about or resting upon herbage in the vicinity of water.

The body is depressed, elongated, and with the sides nearly par-

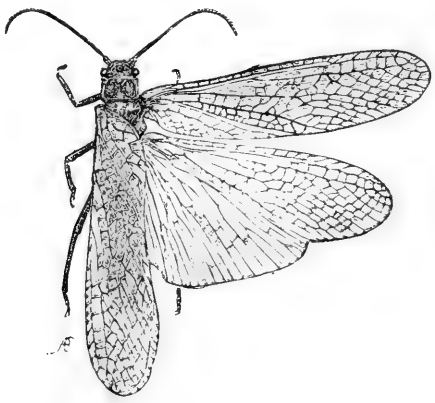

FIG. 72.—*Pteronarcys regalis.*

allel (Fig. 72). The prothorax is large. The antennæ are long, tapering, and many-jointed. The wings are unequal, the second pair being the larger, and lie upon the abdomen when at rest. The tarsi are three-jointed; and in most species the caudal end of the abdomen is furnished with two setæ.

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* Pĕrlidæ, Pĕrla: a proper name.

† Plecŏptera: *plecos* (πλέκος), plaited; *pteron* (πτερόν), a wing.

It is easy to obtain the nymphs of these insects; by lifting stones from the water of swiftly flowing streams the young stone-flies may be found closely adhering to their lower surface. They present a wonderfully flattened appearance (Fig. 73): the body is depressed, and closely applied to the stone; while the legs, antennæ, and caudal setæ radiate from it on the surface of the stone. In our common forms there is a tuft of hair-like tracheal gills just behind the base of each leg. And the more mature individuals present conspicuous wing-pads.

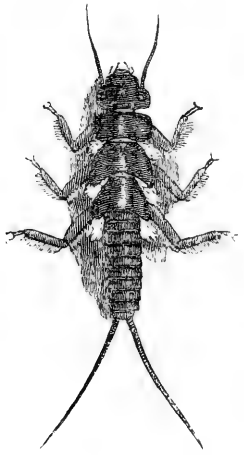

FIG. 73.—Nymph of Stone-fly, *Acroneura*.

The nymphs of stone-flies constitute an important element in the food of fishes. I have found them more often than any other insects in the stomachs of brook trout.

When about to transform to the adult state the insect crawls from the water upon a stone or some other object. Their exuviæ are common in these situations. The females of certain exotic species have been observed to carry their eggs about with them, attached in a globular mass to the end of the abdomen, for some time before they are laid in the water. Probably our species present a similar habit.

The greater number of our species belong to the genus *Perla*. In this genus the wings have but few transverse veins; the anal space of the posterior wings is large and folded; the palpi are bristle-like; and there are two caudal setæ. The genus *Pteronărcys* (Fig. 68) is of great scientific interest, owing to the presence of tracheal gills throughout the entire life of the insects. The gills of Pteronarcys consist of little tufts of short slender filaments, of which there is a pair on the ventral aspect of each thoracic, and the first and second abdominal segments. The wings in this genus are densely net-veined.

There are several species of stone-flies that appear in the adult state upon the snow on warm days in the latter half of winter. They become more numerous in early spring, and often find their way into our houses. The most common one in Central New York is the small snow-fly, *Căpnia pygmæa*. It is black, with gray hairs. The female measures 9 mm. in length, and has an expanse of wings of 16 mm. The male measures only $4\frac{1}{2}$ mm. (0.18 inch), and has

short wings which extend only two-thirds the length of the abdomen.

In England certain stone-flies are much used by anglers. One, *Chloroperla viridis*, is well known under the name "Yellow Sally," and a species of *Nemoura* is called the "Willow-fly.'

Family IV.—TERMITIDÆ.*

(*Termites, or White-ants.*)

The Termites, or white-ants, are social insects, which live in large societies, consisting of several distinct forms of individuals. They are chiefly tropical; but there is one species which is commonly distributed over the United States east of the Rocky Mountains; and several others occur farther west.

These insects can be easily recognized by the pale color of the greater number of individuals of which a colony is composed, by the fact of their living in large ant-like colonies, and by the form of the abdomen, which is broadly joined to the thorax instead of being pedunculate as in the ants.

The Termites are commonly called white-ants on account of their color and of a resemblance in form and habits to the true ants. These resemblances, however, are only very general. In structure the Termites and ants are widely separated; as the former are among the lowest of winged insects, while the latter stand near the head of the series. In habits there is little more in common than that both are social, and the fact that in each the function of reproduction is restricted to a few individuals, while the greater number differ in form from the sexually mature males and females, and are specially adapted to the performance of the labors of the community.

This development of distinct castes for the performance of special functions is carried much farther among the Termites than it is among the ants and other social Hymenoptera. In the latter there are only three forms: males, females or queens, and workers, which are imperfectly developed females. With the Termites there are nearly three times as many.

If a white-ants' nest be opened at any season of the year there will be found a large number of individuals of a dirty-white color,

* Termitidæ: *Termes*, a white-ant.

and of the form represented in Fig. 74. These are named the *workers*, for upon them devolve nearly all the labors of the colony. They may be looked upon as individuals, whose physical, and especially sexual, development has been checked while yet nymphæ and never carried farther. But the development of their instinctive powers is truly remarkable; for it is this caste that builds the nests, collects the provisions, and cares for the young. A study of the internal anatomy of workers has shown that both sexes are represented in this caste; the reproductive organs are, however, but little developed.

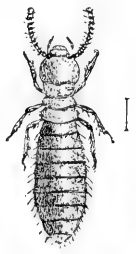

FIG. 74.—*Termes flavipes*, worker.

Associated with the workers, and resembling them in color and in being wingless, there occur numerous representatives of another caste, which can be recognized by the enormous size of their heads (Fig. 75). These are the *soldiers*. Upon this caste devolves the protection of the colony. And they are well adapted for this work, their powerfully developed mandibles rendering them formidable creatures. We find among the soldiers, as among the workers, both sexes represented. In some species the male and female soldiers differ externally, so that they can be distinguished without dissection. But here, as with the workers, the reproductive organs are rudimentary.

FIG. 75.—*Termes flavipes*, soldier.

At a certain season of the year, late spring or early summer for our common species, there can be found in the nests winged individuals; these are the *males* and *females*. These differ greatly in appearance from the workers and soldiers. In our species, *Termes flavipes*, they are black or dark chestnut in color; the body measures 5 mm. (0.2 in.) in length; while the wings expand 16 mm. (0.63 in.). The wings when not in use are placed lengthwise upon the back, and project more than half their length beyond the end of the body. The two pairs of wings are of nearly equal size, and are furnished with numerous veins. In May or June these winged males and females leave the nest in a body. Sometimes clouds of them appear. After flying a greater or less distance they alight on the ground, and then shed their wings. At this time the males seek the females, seizing hold of them with their mandibles; but it is believed that pairing does not take place till a later period. The

greater number of the individuals composing one of these swarms soon perish. They fall victims to birds and other insectivorous animals. But in a few cases a couple is taken in charge by some workers; and thus is founded a new colony. There is usually at the head of a colony only a single pair of sexual individuals. These have been termed the King and Queen. It should be borne in mind, however, that they are simply the parents of the community; for all of the individuals in a colony, except the founders who "elected" this King and Queen, are their offspring; and in no case among insects do we find rulers at the head of a community. It would have been better in each case had the term Mother been applied to the individual at the head of a colony of Termites, ants, bees, or wasps; as the function of such an individual is merely the production of eggs. A cell is provided by the worker Termites for their King and Queen. This is shaped like an inverted watch-glass, and is furnished at first with a single small opening; later there are several. Within this cell the royal pair remain prisoners; but they are carefully attended by numerous workers. As the eggs develop in the body of the female her abdomen becomes greatly extended. Fig. 76 represents such a queen, natural size. The specimen figured is from India, and was kindly given to me by Dr. Hagen. The dark spots along the middle of the dorsal wall of the abdomen are the chitinized parts of that region; the lighter portions are made up of the very much stretched membrane uniting the segments; along each side of the abdomen the spiracles are visible. This specimen is a comparatively small one; in some species the queens become six or eight inches in length.

FIG. 76.—Queen white-ant, *Termes gilvus.*

In addition to the winged males and females just described, there are sometimes developed wingless sexual individuals which never leave the nest. These are termed *complemental males* and *females;* and they serve as substitutes for the winged males or females whenever a community does not find a true king or queen. The complemental females produce comparatively few eggs, and consequently never become as large as do the true queens. It requires several of these to replace a queen. Fritz Müller found in one case a king living in company with thirty-one complemental females. As these wingless males and females never leave the nest,

they pair with their near relatives. The development of winged sexual forms is therefore necessary in order to provide for intercrossing of individuals not closely related. Doubtless here as with the true ants the winged males and females emerge from many nests at the same time and mingle in a single swarm; in this way there is opportunity for intercrossing.

From the above it can be seen that among the Termites there are four distinct castes: (1) Winged sexual forms or kings and queens; (2) Wingless sexual forms or complemental males and females; (3) Workers; (4) Soldiers. As both sexes are represented in each caste, we have in all eight forms.

There is space here for but little regarding the habits of these wonderful insects. In the tropics certain species build nests of great size. Some of these are mounds ten or twelve feet in height. Other species build large globular masses upon the trunks or branches of trees. All of the Termites are miners, and all avoid the light. They therefore build covered ways from their nests to such places as they wish to visit. In some of the hot countries they are the worst of all pests. They will feed upon almost any organic matter; they destroy wooden structures of all kinds, including buildings and furniture. Libraries are often completely ruined by them. In infesting anything composed of wood they usually eat out the interior, leaving a thin film on the outside. Thus a table may appear to be sound, but crumble to pieces beneath a slight weight; entrance having been made through the floor of the house and the legs of the table.

The mounds of Termites are composed chiefly of the excreted undigested wood upon which the insects have fed.* This is moulded into the desired form, and, on drying, it becomes solid.

Like other Pseudoneuroptera, the Termites undergo an incomplete metamorphosis. The eggs as soon as they are deposited by the queen are carried away by the workers to other chambers. The young are fed upon prepared food, which is stored up in the form of very hard and tough rounded masses, evidently composed of comminuted wood. It is believed that the young Termites are also fed on the sclerotia of some fungi. The young white-ants are active; and all sizes, from the newly-hatched nymph to the full-grown

* That this substance is composed largely of woody tissue is easily seen by a microscopic examination; and I am informed by Prof. J. C. Branner, who has observed these insects in Brazil, that he has seen the Termites eject the matter from the caudal opening of the alimentary canal and add it to the nest or covered ways which they were building.

worker, can be found in a nest at the same time. At certain seasons of the year the nymphs of the kings and queens are present, and can be distinguished by their wing-pads of greater or less length.

Termes flavipes is common throughout the Eastern United States; and it is the only species which occurs in this region. The workers when full grown measure about 4 mm. (0.16 in.) in length, and are of the form shown in Fig. 74. The soldiers are somewhat larger; one is represented in Fig. 75. The winged males and females are described above; they are often found in nests before they have swarmed out, and swarms of them are frequently seen. But, notwithstanding the abundance of nests of this species, the laying queen has never been found. A specimen supposed to be a queen was collected in Florida by Mr. Hubbard, and is in the Museum of Comparative Zoology at Cambridge; but this is believed by Dr. Hagen to be merely a complemental female.

Termes flavipes is not a mound-builder. It makes its nests in old logs, in stumps, in the ground under stones or other objects, and in buildings or other wooden structures. It usually infests decaying wood in the fields or forests; but I have known of several instances where it has done serious injury to buildings; and I have also found it infesting living plants. This habit of infesting growing plants is manifested chiefly in the Southern States; but it has been observed also in New England. I found the white-ants common throughout Florida, infesting orange-trees, guava-bushes, and sugar-cane. In this State these insects are generally recognized as important pests. They are there known as "wood-lice," a name whose use is to be deprecated, as it tends to create confusion.

When white-ants infest living plants, they attack that part which is at or just below the surface of the ground. In the case of pampas-grass the base of the stalk is hollowed; with woody plants, as orange-trees and guava-bushes, the bark of the base of the trunk is eaten, and frequently the tree is completely girdled; with sugar-cane the most serious injury is the destruction of the seed cane.

The white-ants may be destroyed by water heated sufficiently to kill the insects without injury to the infested plants. In the case of orange-trees much can be done to prevent the attacks of these insects. My experience convinces me that it is those trees about the crown of whose roots the soil has been heaped that are most liable to become infested. It follows that care should be taken to remove such soil immediately after each cultivation of the grove, leaving the crown of the roots exposed. It is also important to remove all old

wood, especially pine, from near the trees; as such wood is liable to become infested, and the white ants to spread from it to the orange-trees.

The zoological position of the Termitidæ is, like that of the Ephemeridæ, near the foot of the insect series. In fact, the form of the wings with *Termes* is regarded as even more primitive than that of *Ephemera;* as is also the structure of the thorax, with its equally developed and unusually distinct segments. But the wonderful development of instinctive powers and of separate castes among the white-ants indicates that, although as shown by their structure, they represent one of the lowest groups of winged insects preserved to this time, they constitute the highest development of their line. It is a suggestive fact that Hagen, who is the best informed regarding the Termitidæ, considers them closely related to the Blattidæ, to which the oldest known insects belong.

Family V.—Psocidæ.*

(*Book-lice et al.*)

The best known representatives of this family are the minute insects common in old papers, books, and neglected collections; and which have received the name of Book-lice. These low, wingless creatures form, however, but a small part of the family. The more typical and winged forms (Fig. 77) bear a strong resemblance to plant-lice or Aphides. The body is oval, the head free, and the prothorax is small. The wings when present are of unequal size, the hind pair being smaller. When not in use the wings are folded roof-like over the body, like those of the Aphides. The tarsi are two- or three-jointed.

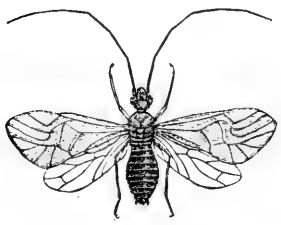

Fig. 77.—*Psocus venosus.*

There are two sub-families, which are distinguished as follows:

A. Ocelli wanting; wings absent or incomplete. Atropinæ.
AA. Ocelli present; wings well developed. Psocinæ.

Atropinæ.—Two genera of this sub-family are represented in this country. In *Ătropos* the wings are absent, the meso- and metathorax are grown together, and the antennæ are seventeen-jointed. The common Book-louse is *Ătropos divinatōria.* This species is about 1 mm. in length; it is grayish white, with black eyes. Closely allied to this genus is *Clothilla,* in which the anterior wings are represented by small convex scales; the meso and metathorax are free, and the antennæ are many-jointed.

*Psŏcidæ, Psōcus: *psocho* (ψώχω), to grind.

C. pulsatōria is a little more than 1 mm. in length. It is of a pale yellowish white, and is found in similar situations as the book-louse.

PSOCINÆ.—Here we find four well-developed wings. Usually these extend much beyond the end of the abdomen. But short-winged forms occur in species which ordinarily are long-winged. Of course the young of all are wingless, and there is a gradual development of the wings as the insect matures. The antennæ consist of only thirteen segments; this will enable one to separate the immature forms from the Atropinæ.

The Psocinæ occur upon the trunks and leaves of trees, on stones, walls, and palings. They feed upon lichens, and probably other dry vegetable matter. They are sometimes gregarious. I have often observed communities of a hundred or more closely huddled together on the trunks of orange-trees in Florida, feeding upon lichens.

The eggs are laid in heaps on leaves, branches, and bark; the female covers them with a tissue of threads. It is believed that both sexes have the power of spinning threads similar to those spun by spiders.

Several genera of Psocinæ occur in the United States; but the greater number of our species belong to the genus *Psōcus*.

Family VI.—MALLOPHAGIDÆ.*

Order MALLOPHAGA of some authors.

(*Bird-lice.*)

The *Mallophăgidæ* are parasites which live on warm-blooded animals. They infest chiefly birds, and on this account the term Bird-lice is applied to the entire group. A few genera, however, are parasitic upon mammals. It is an interesting fact that in the case of the genera that infest mammals none of the species are found on birds; and of those that live on birds none infest mammals.

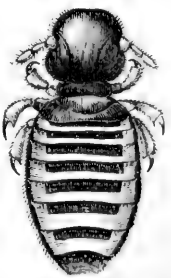

FIG. 78.—*Trichodectes equi.* (From Law.)

The bird-lice resemble the true lice in form, being wingless, and with the body more or less flattened. Certain species which infest domestic fowls are well-known examples. These insects differ from the true lice in having biting mouth-parts. They feed upon feathers, hair, and dermal scales, while the true lice (Family Pediculidæ, Order Hemiptera) have sucking mouth-parts, feed upon blood, and infest only mammals.

* Mallŏphaga: *mallos* (μαλλός), wool; phagein (φαγεῖν), to eat.

Menōpon păllidum is one of the species which infest the hen. This is often a pest in hen-houses. It is to free themselves from this and allied parasites that hens wallow in dust and scatter it among their feathers. When fowls are confined so that they cannot dust themselves they are very liable to suffer from bird-lice.

In order to protect fowls from these pests, cleanliness and the use of proper insecticides are necessary. The house should be thoroughly cleaned at least twice each year, and the straw in the nests burned. Sprinkling powdered sulphur in the nests, and oiling the perches with kerosene, will do much to keep the lice in check. If a house becomes badly infested it should be thoroughly white-washed, and the fowls dusted with Persian insect-powder. Many writers advise the use of kerosene upon infested fowls.

There is much doubt regarding the zoological position of the Mallophaga. The placing of them in the Pseudoneuroptera must be regarded as a provisional arrangement. They were formerly classed with the true lice, but they are sharply distinguished from them by the structure of their mouth-parts. Both of these groups have become so degraded as the result of their parasitic habits that it will be very difficult if not impossible to definitely determine their places in the insect series. Certain German entomologists class together as an order the Termitidæ, Psocidæ, and Mallophaga under the name *Corrodĕntia*. But this association does not seem to me natural.

TABLE OF GENERA OF MALLOPHAGA.

A. Antennæ filiform, three- or five-jointed; maxillary palpi invisible.
  B. Antennæ three-jointed; tarsi with a single claw. Parasites on mammals. 1. TRICHODECTES.
  BB. Antennæ five-jointed; tarsi with two claws. Parasites on birds.
    C. With movable appendages (trabiculæ) on the head in front of the antennæ; antennæ nearly alike in both sexes. 2. DOCOPHORUS.
    CC. Trabiculæ absent, or if present not motile.
      D. Antennæ filiform, without sexual differences.
        E. Head rounded behind; last segment in the male rounded off. 3. NIRMUS.
        EE. Head abrupt-angled behind; abdominal segments fused in the middle. 4. GONIOCOTES.
      DD. Antennæ of male forcipate by a process from the third segment.
        E. Head angled behind; terminal segments of female tubercle-like, of male rounded off. 5. GONIODES.
        EE. Head rounded behind; terminal segment of male notched. 6. LIPEURUS.

AA. Antennæ clubbed, four-jointed; maxillary palpi long, filiform, four-jointed.
B. Tarsi with two claws. Parasites on birds.
C. Mesothorax wanting; antennæ always concealed.
D. Head very broad; no orbital sinus. 7. EUREUM.
DD. Head elongated, with lateral angles directed backwards.
E. With sharply marked off cypleus, and shallow orbital sinus. 8. LÆMOBOTHRIUM.
EE. With only wavy head-margins, and long lateral lobes on the labrum. 9. PHYSOSTOMUM.
CC. Mesothorax present.
D. Mesothorax large, sharply marked off; head three-sided; antennæ concealed. 10. TRINOTUM.
DD. Mesothorax small, only indicated.
E. Orbital sinus deep; antennæ usually elongated and visible. 11. COLPOCEPHALUM.
EE. Orbital sinus very shallow or obsolete, antennæ concealed. 12. MENOPON.
BB. Tarsi with a single claw. Parasites on mammals. 13. GYROPUS.

The following is a list of the described species of the Mallophaga which infest domestic animals; in each case the host is indicated:

1. TRICHODECTES.—*Trichodĕctes lātus* (Fig. 79), dog; *T. rostrātus*, cat; *T. ĕqui* (Fig. 78), horse and ass; *T. brĕviceps*, llama; *T. clīmax*, goat; *T. spherocĕphalus* (Fig. 80), sheep; *T. scalāris* (Fig. 81), ox.

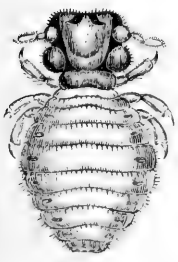

FIG. 79.—*Trichodectes latus.* (From Law.)

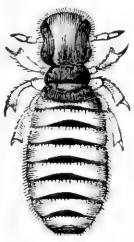

FIG. 80.—*Trichodectes spherocephalus.* (From Law.)

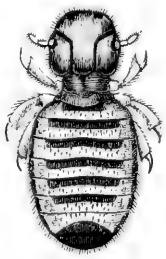

FIG. 81.—*Trichodectes scalaris.* (From Law.)

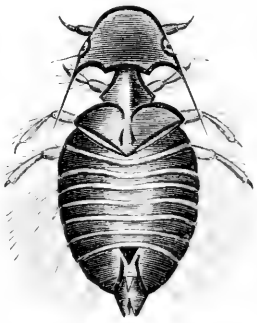

FIG. 82.—*Goniodes stylifer.* (From Law.)

2. DOCOPHORUS.—*Docŏphorus adŭstus*, goose; *D. icterōdes*, duck.

3. NIRMUS.—*Nĭrmus clavæfŏrmis*, pigeon; *N. nūmidæ*, Guinea-fowl; *N. tessellātus*, duck.

4. GONIOCHOTES.—*Goniŏchotes cŏmpar*, pigeon; *G. sp.*, Guinea-fowl; *G. rectangulātus*, peacock; *G. chrysocĕphalus*, pheasant; *G. hologăster*, hen.

5. GONIODES.—*Goniŏdes numidiānus*, Guinea-fowl; *G. stylifer* (Fig. 82),

turkey; *G. falcicŏrnis*, peacock; *G. cŏlchicus*, pheasant; *G. dissĭmilis* and *G. gigas*, hen.

6. LIPEURUS.—*Lipeūrus bacĭllus*, pigeon; *L. polytrapēsius*, turkey; *L. sp.*, peacock; *L. heterŏgraphus* and *L. variābilis*, hen; *L. lăcteus* and *L. jejūnus*, goose; *L. squălidus* and *L. variābilis*, duck.

10. TRINOTUM.—*Trinŏtum conspurcātum* and *T. squălidum*, goose; *T. conspurcātum*, swan; *T. lūridum*, duck.

11. COLPOCEPHALUM.—*Colpocĕphalum longicaudum*, pigeon; *C. minūtum*, swan.

12. MENOPON.—*Menŏpon nūmidæ*, Guinea-fowl; *M. stramĭneum*, turkey; *M. phacŏstomum*, peacock; *M. fuscomaculātum*, pheasant; *M. pallĭdum*, hen.

13. GYROPUS.—*Gyropus grăcilis* and *G. ovālis*, capybara.

CHAPTER VI.

Order III.—ORTHOPTERA.*

(*Cockroaches, Crickets, Grasshoppers, Locusts, Earwigs, et al.*)

The members of this order have four wings: the first pair are thickened, and usually overlap when at rest; the second pair are thinner, and are folded in plaits longitudinally. The mouth parts are formed for biting. The metamorphosis is incomplete.

The order Orthoptera includes some of the very common and best known insects. The most familiar representatives are the cockroaches, crickets, grasshoppers, locusts, and katydids.

Although the song of the katydid and the chirp of the cricket are most often associated with recollections of pleasant evenings spent in the country, we cannot forget that to members of this order are due some of the most terrible insect scourges man has known. The devastations caused by great swarms of migratory locusts are not only matters of historical record, but are too painfully known to many of our own generation in the Western States.

With the exception of a single family (Mantidæ), the members of this order are as a rule injurious to vegetation. And many species are quite apt to multiply to such an extent that their destruction of plant life becomes of economic importance.

In the Orthoptera the two pairs of wings differ in structure. The front wings are leathery or parchment-like, forming covers for the more delicate hind wings. These wing-covers have received the special name *tegmina*. Excepting in the first family (the earwigs), the tegmina of the Orthoptera are thickly reticulated with a net-work of veins, and usually overlap at the tips. The position and structure of the tegmina differ in the different families, and afford good characters for separating them. The more important veins of the tegmina usually divide them into three more or less well-marked fields or areas. These have been named, beginning with that bordering on the front margin of the wing, the costal, median, and anal areas, respectively. The hind legs are thickly netted with veins.

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* Orthŏptera: *orthos* (ορθός), straight; *pteron* (πτερόν), a wing.

The principal ones are arranged somewhat like the bars of a fan; and the wings when not in use are folded in a fan-like manner. The name Orthoptera is given to this order on account of this longitudinal folding and position of the second pair of wings when closed.

There are many wingless genera in the order. A few species have the anterior pair only; and in one instance at least, the first pair are wanting while the second pair are present.

The mouth parts are all present, and are well developed. The student who wishes to get a clear idea of the structure of a typical insect's mouth cannot do better than to dissect the mouth of a cockroach or locust.

The appendages of the abdomen furnish important characters for the purposes of classification. Thus the form of the ovipositor is of great service in distinguishing the families; and the *cĕrci*, a pair of appendages one on each side near the caudal end of the abdomen, are also much used in descriptions.

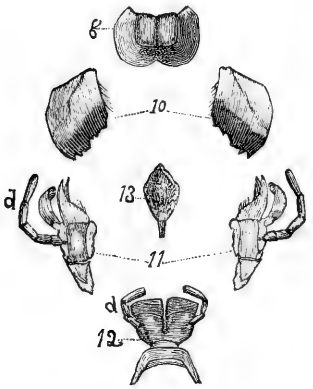

FIG. 83.—Mouth-parts of the Red-legged Locust.

In the Orthoptera the metamorphosis is incomplete. In the case of those species that never acquire wings the change in form from the newly hatched nymph to the adult is frequently inconsiderable. With others we see the wings, developed by degrees, as described in Chapter I. (Figs. 8 to 13).

There are many Orthoptera that have in the adult state only rudimentary wings. These resemble very strongly immature insects. It is often important to determine whether a short-winged specimen is an adult or not; this is especially true in case of the *Acrididæ*, or locusts. Fortunately this determination can easily be made with the Jumping Orthoptera (section Saltatoria). In case of these insects the wing-pads of the nymphs are inverted, as shown by the curving down of the extremities of the wing-veins instead of up, as with the adult; and the rudimentary wings are outside of the wing-covers, instead of beneath them. There is also the distinction that these rudiments of the second pair of wings are triangular in outline, and are flat, not folded; while the wings of the adult are more or less folded, even when too small to be of use as organs of flight.

Certain species belonging to the three higher families, Acrididæ,

Gryllidæ, and Locustidæ, are interesting on account of the sounds which they produce. A very large proportion of the insect cries heard in the late summer and autumn come from this source. The organs by which these notes are made are chiefly the wing-covers. It should be remembered that, owing to their peculiar mode of breathing, insects have nothing that corresponds to our voice. It is only the males of the Orthoptera that sing; and the musical apparatus is different in each of the three families. Each form will be described later.

In this connection perhaps reference should be made to the supposed organs of hearing of these insects. In the Acrididæ there is on each side of the first abdominal segment a pit, over the mouth of which is stretched a membrane: this is termed the *tympanum*, and is believed by some to be an organ of hearing; it is doubtless a sense-organ, but its function has not yet been determined. A pair of similar organs occur near the proximal end of each tibia of the first pair of legs in the Locustidæ and Gryllidæ.

The order Orthoptera comprises seven families. These have been grouped into five sections by some writers; and the names of the sections occur frequently in entomological works. Each of the first four sections includes only a single family; the fourth section includes the three remaining families. The names of the sections except the first were suggested by the form of the legs in each. The following are the names of the sections and the families which they include:

I. *Dermăptera;* includes the *Forficūlidæ* or Earwigs.
II. *Cursōria* or Runners; includes the *Blăttidæ* or Cockroaches.
III. *Raptōria* or Graspers; includes the *Măntidæ* or Rear-horses.
IV. *Ambulatōria* or Walkers; includes the *Phăsmidæ* or Walking-sticks.
V. *Saltatōria* or Jumpers; includes the *Acrĭdidæ* or Locusts or Short-horned Grasshoppers, the *Locŭstidæ* or Long-horned Grasshoppers and Katydids, and the *Grўllidæ* or Crickets.

TABLE OF FAMILIES OF ORTHOPTERA.

A. Posterior femora fitted for walking, i.e., resembling those of the other legs; ovipositor with the subgenital plate concealed; organs of flight of immature forms in normal position; insects mute.

B. Anterior wings leathery, very short, without veins, meeting in a straight line; posterior wings when present folded to the middle of the anterior

margin; tarsi three jointed, the pulvillus wanting; cerci horny, resembling forceps. 1. FORFICULIDÆ.

BB. Anterior wings parchment-like, thickly veined; posterior wings folded to the base; tarsi five-jointed; cerci soft, jointed or without joints.

C. Body oval, depressed; head wholly or almost wholly withdrawn beneath the pronotum; pronotum shield-like, transverse; legs compressed; cerci jointed; rapidly running insects. 2. BLATTIDÆ.

CC. Body elongated; head free; pronotum elongated; legs slender, rounded; cerci jointed or without joints; walking insects.

D. Front legs fitted for grasping; cerci jointed. 3. MANTIDÆ.

DD. Front legs simple; cerci without joints. 4. PHASMIDÆ.

AA. Posterior femora fitted for jumping, i.e., very much stouter or very much longer, or both stouter and longer than the middle femora; ovipositor horny, free (except with the mole crickets); organs of flight of immature forms inverted; stridulating insects.

B. Antennæ short; tarsi three-jointed; supposed organs of hearing situated in the first abdominal segment; ovipositor short, composed of four separate plates; stridulating organs situated in hind femora and the costal area of the tegmina. 5. ACRIDIDÆ.

BB. Antennæ long, setaceous; tarsi four- or three-jointed; supposed organs of hearing situated in the anterior tibiæ and also in the prosternum; ovipositor elongated (except in the mole crickets); composed of four connate plates.

C. Tarsi four-jointed; ovipositor (when exserted) forming a strongly compressed, generally sword-shaped blade; the stridulating organs of male limited to the anal area of the tegmina. 6. LOCUSTIDÆ.

CC. Tarsi three-jointed; ovipositor (when exserted) forming a nearly cylindrical, straight, or occasionally upcurved needle; the stridulating organs of the male extend across the anal and median areas of the tegmina. 7. GRYLLIDÆ.

Family I.—FORFICULIDÆ.*

(*Earwigs.*)

This family includes only the earwigs. With these insects the first pair of wings are leathery, very small, without veins, and when at rest meet in a straight line down the back, partially covering the second pair of wings. These wing-covers strongly resemble those of the rove-beetles. The second pair of wings differ from those of other Orthoptera (Fig. 84). They are furnished with radiating veins which extend from a point near the end of the basal third of the

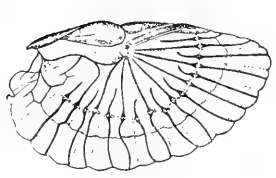

FIG. 84.—Wing of Earwig.

* Forficŭlidæ: *forfĭcula*, a pair of small shears.

wing over the distal part of this organ. When the wing is not in use this part is folded in plaits like a fan; and the wing is folded twice transversely. With other Orthoptera the longitudinal folding extends to the base of the wing, and there is no transverse folding. The tarsi are three-jointed; and there are no pulvilli between the claws. The most striking character of the family is the form of the cerci, which are horny, and resemble forceps.

The earwigs are rare in this country, especially in the North. But in Europe they are common, and are often troublesome pests. They are nocturnal, hiding in the day-time among leaves and in all kinds of crevices, and coming out by night. They feed upon the corollas of flowers, fruit, and other vegetable substances. When troublesome, they may be trapped with hollow objects into which they can crawl and hide during the day-time.

The name of the typical genus, *Forficula*, is the Latin word for scissors. It was suggested by the curious form of the cerci. The common name, earwig, has reference to a widely spread fancy that these insects creep into the ears of sleeping persons.

Our most common representative of the family is the little earwig, *Labia minor*. This is a small species; the body measures a little less than 4 mm. (0.15 inch) in length; the forceps of the male, 1.25–2 mm. (0.05–0.08 inch); and those of the female slightly less. The head is blackish; the pronotum is narrower than the head; and the wings protrude beyond the tips of the tegmina.

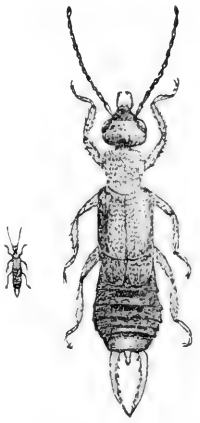

FIG. 85.—An Earwig.

In 1876 only 13 species of this family were known to occur in the United States. For a tabular synopsis of these by S. H. Scudder, see Psyche, vol. I. p. 177.

It is thought by many entomologists that this family should rank as an order; and it is so classed in some of the text-books under the name *Dermaptera*, and in others under the name *Euplexoptera*.

Family II.—Blattidæ.*

(*Cockroaches.*)

The cockroaches are such well-known insects that there is but little need for a detailed account of their characteristics. As already indicated in the table of families, the body is oval and depressed; the head is nearly horizontal, and wholly or almost wholly withdrawn beneath the pronotum; the head is bent so that the mouth parts project caudad between the bases of the first pair of legs; the antennæ are long and bristle-like; and the pronotum is shield-like. This family includes only the cockroaches; but these insects are known in some localities as "black beetles," and our most common species in the Northern cities bears the name of Croton-bug.

In the Northern States our native species are usually found in the fields or forests under sticks, stones, or other rubbish. But certain imported species become pests in dwellings. In the warmer parts of the country, however, native and foreign species alike swarm in buildings of all kinds, and are very common out of doors.

Cockroaches are very general feeders: they destroy nearly all forms of provisions, and injure many other kinds of merchandise. They often deface the covers of cloth-bound books, eating blotches upon them for the sake of the sizing used in their manufacture; and I have had them eat even the gum from postage-stamps. They thrive best in warm, damp situations; in dwellings they prefer the kitchens and laundries, and the neighborhood of steam and water pipes. They are chiefly nocturnal insects. They conceal themselves during the day beneath furniture or the floors, or within the spaces in the walls of a house; and at night they emerge in search of food. The depressed form of their bodies enables them to enter small cracks in the floors or walls.

Not only are these insects very destructive to our possessions, but owing to their fetid odor merely the sight of them awakens disgust; but it is due them to state that they are said to devour greedily bed-bugs. This will better enable us to abide their presence in our state-rooms on ocean voyages, or in our chambers when we are forced to stop at poor hotels.

It is a curious fact in the life-history of cockroaches that the female lays all of her eggs at once, they being inclosed in a purse-

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* Blăttidæ: *blătta*, a cockroach.

like pod (Fig. 86). This pod varies in form in different genera; but is more or less bean-shaped. Upon one edge there is a longitudinal slit. Within, the capsule is divided into two spaces, in each of which there is a row of separate chambers, each chamber enclosing an egg. The females carry this pod, or oötheca, as it is termed, about with them, protruding from the end of the abdomen for several days.

Fig. 86.—Ootheca of a Cockroach.

The use of Pyrethrum or Persian insect-powder is the most efficient means of ridding an infested house of these pests. It should be sprinkled about their haunts at night, or blown into the cracks from which they come. (See Chapter XIV., Pyrethrum).

The Croton-bug (*Blátta germánica*).—This is the best known of all of the cockroaches in our Northern cities. The above popular name originated in New York City, and was suggested by the fact that these pests are very abundant, in houses, about the water-pipes connected with the Croton Aqueduct. The adult insect varies in length from 11 mm. to 13 mm. (0.43 in. to 0.51 in.). It is light brown in color, with two longitudinal black stripes on the pronotum. The wings extend beyond the tip of the abdomen. This is an imported species, which has spread to nearly all parts of the world, living upon ships, and spreading from them. (Fig. 87.)

Fig. 87.—The Croton-bug.

The Oriental Cockroach (*Periplanēta orientālis*).—This also is a cosmopolite, which, like the preceding species, is a great pest in dwellings throughout the civilized world. It is dark brown, and measures from 20 mm. to 23 mm. (0.8 in. to 0.9 in. in length). With the females the tegmina are only about 4 mm. in length, and have no wings under them. In the males both pairs of wings are developed, but do not reach to the end of the abdomen.

Of our native species there are two which I have found very common at the North. *Ectōbia flavocincta* is a blackish-brown species, about 16 mm. (0.63 in.) in length, with a light stripe extending on each side from the head along the margin of the pronotum and the basal half of the tegmina. The wing-covers do not quite reach the tip of the abdomen. *Platamōdes pennsylvánica* is a much larger species, with long delicate light-colored tegmina and wings. These extend beyond the tip of the abdomen. The margin of the pronotum is light, while the disk is dark; and the lateral margins of the tegmina,

especially at the base, are lighter than the discal portions. The adult measures to the tip of the wings 25 mm. (1 inch) or more. Although this is a native species, living in our fields, it is often found in our dwellings, being attracted by lights at night.

FIG. 88.—A wingless Cockroach.

Among our species of cockroaches are many wingless forms. One of these is represented in Fig. 88.

Family III.—MANTIDÆ.*

(*The Soothsayers or Praying Mantes.*)

The members of this family have received many popular names in the regions where they occur, owing to their grotesque forms and strange attitudes. Among these are Rear-horses, Race-horses, Camel-crickets, Praying Mantes, and Soothsayers. The

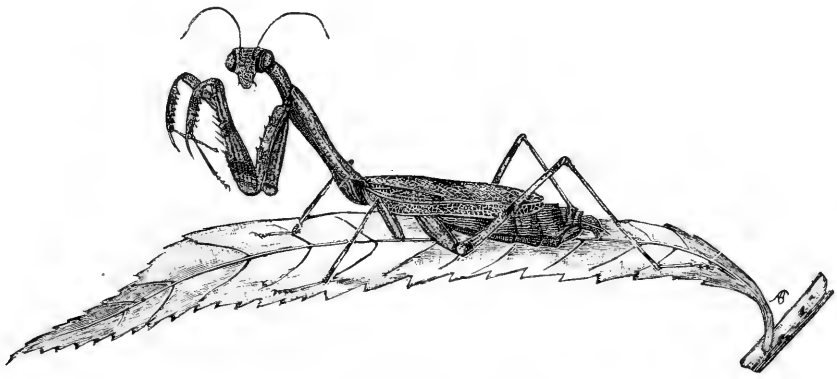

FIG. 89.—*Phasmomantis carolina.*

species are usually of considerable size, so that they are conspicuous objects. We have no representative of the family at the North; and there are but few species in our Southern States, they being chiefly inhabitants of tropical countries.

The most striking characters of these insects are the great length of the prothorax, it being the longest segment of the body, and the enlarged front legs, which are fitted for grasping. With some species the wings resemble leaves of plants in form and coloring. This resemblance is protective, causing the insects to resemble twigs of

* Mantidæ, Mantis: *mantis* (μαντις), a prophet; also the Greek name for these insects.

the plants upon which they are. All of the species are carnivorous. They do not pursue their prey, but wait patiently with the front legs raised like uplifted hands in prayer, until it comes within reach, when they seize it. This position which they assume while waiting gives them most of their popular names. The eggs of the Mantidæ are laid in clusters on twigs, and encased in a flattened case or oötheca (Fig. 90). This differs from the oötheca of the cockroach in being composed of hardened silk.

Fig. 90.—Egg-masses of *P. carolina*. (From Riley.)

The most common species of the Southern States is *Phasmomăntis carolīna*. This is shown by Fig. 89. By referring to this figure the unusual development of the front legs can be seen. The parts of the leg that are most strongly spined are the femur and tibia; the slender tarsus appears as an appendage of the tibia; and the coxa is so elongated that at first sight it would be mistaken for the femur.

Family IV.—Phasmidæ.*

(*Walking-sticks.*)

Even more grotesque in appearance than the Mantidæ are the insects constituting the family Phasmidæ, and commonly known as Walking-sticks, or Spectres. They can be easily recognized by their long, linear bodies, furnished with long legs and antennæ. The three pairs of legs are similar in form. Their wings, when present, are small, or if large, very leaf-like; resembling in some instances fresh green leaves, in others, those that are dry and withered. The wingless species often resemble twigs.

The Walking-sticks are strictly herbivorous; they are slow in their motions, and often remain quiet for a long time in one place. Their eggs are large, oval, and are scattered on the ground beneath the plants upon which the insects feed, the female, unlike most Orthopterous insects, making no provision for their safety.

These insects are chiefly tropical. Only a single species is common in the Northeastern United States. This is *Diapherŏmera fe-*

* Phăsmidæ, Phăsma: *phasma* (φάσμα), a spectre.

morāta. It is represented in Fig. 91, natural size. It is a quite common insect; and on several occasions has appeared in such great

FIG. 91.—*Diapheromera femorata*. *a*, *b*, eggs; *c*, young hatching. (From Riley.)

numbers as to be seriously destructive to the foliage of forest trees. Probably the best way of destroying it when it becomes a pest is to spray the infested trees or shrubs with Paris-green water, and its

recurrence should be guarded against by burning the leaves upon the ground under the infested trees in the autumn, thus destroying the eggs.

Family V.—Acrididæ.*

(*Locusts or Short-horned Grasshoppers.*)

The Acrididæ and the two following families constitute the section *Saltatōria* or Jumpers. The members of this section agree in having the hind legs fitted for jumping, by being either very much stouter or very much longer, or both stouter and longer, than the femora of the other legs. The females are usually furnished with a prominent ovipositor, and the wings of the immature forms are in an inverted position.

In many species, especially of the Acrididæ, the adult is furnished with rudimentary wings; and thus presents the appearance of an immature form. But by means of the character just given it is easy to distinguish the adult even in the case of these short-winged species; for in the immature forms the tegmina are folded beneath the wings, and the principal veins of both tegmina and wings curve downward instead of upward.

The family *Acrididæ* includes the Locusts or Short-horned Grasshoppers. These are common and well-known insects. They differ from other Saltatoria in having the antennæ much shorter than the body, and consisting of not more than twenty-five segments. The ovipositor of the female is short, and composed of four separate plates, and the basal segment of the abdomen is furnished on each side with a supposed organ of hearing.

The head is usually short, although in two of the sub-families it is extended horizontally. Immediately under the vertex, but in some cases above it, there is on each side a little space bounded by elevated ridges. These spaces are termed the *lateral fovĕolæ;* their variations in form afford characters which are much used in classification. The front is generally traversed by three vertical keels or *carīnæ;* the one on the middle line is termed the *median carīna* or *frontal cŏsta*, the others are the *lateral carīnæ*. The pronotum is divided into four lobes by three more or less well-marked transverse sutures; it is also often furnished with a median crest. The hind tibiæ carry upon the upper side two rows of spines: the num-

* Acrĭdidæ, Acrĭdium: *acridion* (ἀκρίδιον), a small locust.

ber of these is of use in distinguishing species; and the presence or absence of the last spine in the outer row is of much greater importance. Besides these spines there are four articulated spurs, which are situated in two pairs, one on the outer and one on the inner side of the tibia. The sexes can be easily distinguished. In the males the ventral surface of the abdomen consists of nine segments, while in the females there are but eight. The caudal end of the body in the females is furnished with four horny appendages, the ovipositor; in the male the ventral pair of appendages is represented by a single plate.

With many species of the Acrididæ we find the males furnished with stridulating organs. These are not nearly so highly developed as those of members of the two higher families, and are used only in the day-time. The Locusts stridulate in two ways. Certain species rub the inner surface of the hind legs against the outer surface of the wing-covers. With these insects there is a thickening of one of the main longitudinal veins in the centre of the wing-cover (*vēna radiālis*), and a remarkable extension of the two areas between this vein and the costal margin of the wing-cover (*ārea scapulāris* and *ārea externomēdia*), which serves as a sounding-board, and which is wanting in the female. The most common representatives of the insects which stridulate in this way belong to the genus *Stenobothrus*. According to Scudder, the Stenobothri, when about to stridulate, place themselves in a nearly horizontal position, with the head a little elevated; then they raise both hind legs at once, and grating the femora against the outer surface of the tegmina, produce notes which in the different species vary in rapidity, number, and duration. The first one or two movements are frequently noiseless or faint; and when the sky is overcast, the movements are less rapid. Scudder has recorded the songs of several species by means of a musical notation.*

The second method of stridulation practised by locusts is by rubbing together the upper surface of the front edge of the wings and the under surface of the wing-covers. Those which employ this method stridulate during flight. Several common species pertaining to the Œdipodinæ will serve as illustrations: *Chimarocephala viridifasciata*, *Eucoptolephus sordidus*, and *Dissosteria carolina*. Certain other closely allied species produce no sound whatever.

Locusts lay their eggs in oval masses, covered with a tough glutinous secretion. Many species deposit them in the ground, the ovipositor of the female being well adapted for making the necessary hole. The tips of the four horny appendages of which it is composed can be alternately applied together and spread apart; in this way it is an easy matter to force the earth aside and press the end of the abdomen into the ground. Fig. 97 represents the Rocky Moun-

* Proc. Bost. Soc. Nat. Hist., vol. XI.

tain locust in the act of ovipositing. Certain species make holes with their ovipositor in a similar manner in fence-rails, logs, stumps, and other masses of wood, in which they deposit their eggs. After the eggs are laid, the entrance to the hole in the wood is closed with a little plug of gummy matter.

The transformations of three of our more common species of *Melanoplus* have been carefully studied by Riley.* These will serve to illustrate the metamorphoses in this family. In each case there are five nymph stages. In the first of these (Fig. 8), although the insect would be readily recognized as a young locust, there is a marked difference in the proportions of the body from those presented by the adult. This is especially noticeable in the large size of the head, the relatively stouter thorax and hind femora, and in the short abdomen. From this form to that of the adult there is presented by the other nymph stages a very regular series of gradations. The most striking change in the course of the development of these insects is the growth of the organs of flight. In the first nymph stage there is no indication whatever of wings; in the second stage the caudo-lateral angles of the mesonotum and metanotum are very slightly prolonged (Fig. 9). In the third stage these prolongations are more marked, and are easily recognized as rudimentary wing-pads (Fig. 10). In the fourth stage a remarkable change has occurred in these organs: up to this point they have projected downward and backward; they are now turned up so that what was their lower edges now meet on the narrow back, and the side of each which was next to the body is now turned outward (Fig. 11). While in this position the second pair of wing-pads is outside of the first—the reverse of the relative positions of the fully developed wings. In the fifth stage the wing-pads are longer, being now about as long as the pronotum (Fig. 12). Up to this point the development of the wings has been very gradual, the most pronounced change being the reversal of these organs between the third and fourth stages. With the moult, which occurs at the end of the fifth stage, the insect assumes the adult form (Fig. 13). The wings have now become greatly elongated; they are again reversed, so that they assume the primitive position, with the second pair folded beneath the first. This completes the changes through which these organs pass.

So far as my observations go, there is but a single generation of each species of locust during a year. In the majority of cases at

* See First Report of the U. S. Ent. Com., Plates I., II., and III.

the North, the species winters in the egg state, and does not become fully developed till the latter part of summer or in the autumn. A few adults survive the winter; and we have a few species in which the eggs hatch in the autumn, and the insects pass the winter in the nymph state.

Many of the Acrididæ never acquire fully developed wings; the way in which these short-winged adults can be distinguished from nymphs has been given in the generalizations regarding the order.

The locusts, or grasshoppers as they are commonly called, are of first-class importance when viewed from an economic standpoint. They feed on all kinds of vegetation, and they abound every year in all parts of our country. Owing to their uniform abundance, they have fallen into the category of the commonplace, and little is said about them. I do not refer here to the migratory species, the incursions of which spread consternation, but to the myriads that swarm in our meadows and pastures every summer and autumn.

Although the injuries caused by our common locusts are very great every year, they are more noticeable in seasons of drought. It frequently happens at such times that every blade of grass is consumed in extensive pastures. This results not merely from the less luxuriant growth of the grass, but from the fact also that dry weather is favorable to the development of these insects.

It follows from the above that such treatment of meadows and pastures as shall best enable them to withstand droughts will also serve to protect them from the ravages of locusts. Thus the presence in the soil of a considerable amount of vegetable matter, furnished in the form of stable manure or otherwise, which will retain moisture, will have this tendency: or clover may be used; this will shade the soil, and will bring moisture and fertility from great depths by means of its long roots. In case of heavy clay lands, tile-draining has been recommended; this prevents the puddling and subsequent baking and cracking of the soil resulting from surface drainage.

TABLE OF SUB-FAMILIES OF ACRIDIDÆ.

A. Pulvilli present between the claws of the tarsi; pronotum never extending over the abdomen.

B. Prosternum unarmed.

C. Vertex and front of head meeting at an acute angle; vertex extending horizontally; front strongly receding. (Fig. 92.) I. TRYXALINÆ.

CC. Head rounded at the union of the vertex and front; front perpendicular, or nearly so. (Fig. 93.)

D. The terminal spine of the outer row of the posterior tibiæ wanting (Fig. 94, *b*); second abdominal segment smooth. II. ŒDIPODINÆ.

DD. The terminal spine of the outer row of the posterior tibiæ present (Fig. 94, *a*); second abdominal segment granulated on the sides. (Fig. 95.) III. EREMOBINÆ.

BB. Prosternum tuberculate, or mucronate, or produced into a cone.

C. Head rounded at the union of the vertex and front; front slightly receding; antennæ filiform. (Fig. 99.) IV. ACRIDINÆ.

CC. Vertex extending horizontally in front of the eyes; front strongly receding; antennæ more or less flattened. (Fig. 102.) V. OPOMALINÆ.

AA. No pulvilli between the claws of the tarsi; pronotum extending over the abdomen. (Fig. 103.) VI. TETTIGINÆ.

Sub-family I.—TRYXALINÆ.*

In the linear arrangement of the sub-families of the Acrididæ there are placed first, i.e., lowest, a series of sub-families in which the prosternum is unarmed. The Tryxalinæ differs from the other members of this series in that the representatives of it have the vertex conical and elongated, the front strongly receding, and the antennæ flattened. The antennæ are inserted between the middle of the eyes or farther from the mouth than their middle; the eyes are usually longer than that part of the genæ below them; the posterior lobe of the pronotum is usually shorter than the anterior part; the median carina is not at all crested; and the last spine of the outer row of the posterior tibiæ is wanting.

The characteristic difference between this family and the next, the Œdipodinæ, is in the joining of the vertex and front, as indicated in the table of sub-families given above. The following species will serve to illustrate the Tryxalinæ:

Achurum brevipĕnne.—This is one of the most grotesque of all our locusts. The body is excessively elongated, being almost linear. In fully grown female specimens it measures more than 40 mm. (1.6 in.) in length; and about 3 mm. (0.12 in.) across in the widest part. The males are somewhat smaller. The head is greatly elongated, and ascending; the front is very strongly receding; the antennæ are a little shorter than the head and prothorax, broad near the base, acuminate at the apex, and triquetrous. The wings are small; when fully developed the tegmina extend a little beyond the third

* Tryxalīnæ, Tryxālis: *tryxallis* (τρυξαλλίς), Greek name of these insects.

abdominal segment. The color of these insects is brown, sometimes marked with minute dark specks.

This species is an excellent illustration of protective form and coloring. I found it quite common in Florida upon the "wire-grass" which grows in the sand among the saw-palmettoes; and so closely did their brown linear bodies resemble dry grass, that it was very difficult to perceive them.

I have also collected this species near the coast as far north as Maryland, but have no other information as to its distribution.

Among the more common representatives of this sub-family in the Eastern United States are two species of the genus *Stenŏbothrus*. In each of these there is on each side on the margin of the vertex in front of the eye a little oblong pit, the lateral foveolæ; and the lateral carinæ of the pronotum are incurved. The more common of the two is the Short-winged Locust, *S. curtipĕnnis*. In this species the lateral foveolæ are linear; the tegmina are unspotted and of a pale reddish brown. In some specimens the tegmina and wings are shorter than the abdomen; in others they are longer. The males measure about 16 mm. (0.63 inch) in length; the females, 21 mm. (0.82 inch).

The next species of this genus in abundance is the spotted-winged locust, *S. maculipĕnnis*. In this species the lateral foveolæ are shallow, and broader towards the eye than at the apex; the tegmina are green, with a median band of equidistant square black spots along its whole extent; sometimes the inner halves of the tegmina are entirely of a rust-red color. Both the tegmina and wings extend beyond the tip of the abdomen. This species is about the same size as the preceding.

In the genus *Chrysŏchraon* the vertex is without foveolæ; and the lateral carinæ of the pronotum are nearly parallel. One of the species, the Sprinkled Locust, *C. conspĕrsum*, is very abundant. It is brown, with the sides of the pronotum and the first two or three abdominal segments shining black in the male; and with the body and tegmina of the female sprinkled or mottled with darker brown. The tegmina and wings are a little shorter than the abdomen in the males, and much shorter in the females. The female is represented by Fig. 92. The males measure 17 mm. (0.67 inch) in length; the females, 23 mm. (0.91 inch).

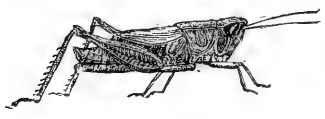

FIG. 92.—*Chrysochraon conspersum.*

Sub-family II.—ŒDIPODINÆ.*

The second of the two more important sub-families in which the prosternum is unarmed, the *Œdipodinæ*, includes genera in which the head is rounded at the union of the vertex and front; and in which the front is perpendicular or nearly so. The antennæ are linear or sub-linear, and usually inserted nearer the mouth than the middle of the eyes; sometimes they are inserted just in front of the eyes. The eyes are small or of medium size; rarely longer than that part of the cheeks below the eyes. The posterior lobe of the pronotum is longer than the anterior part in the typical forms; and the median carina is frequently entirely or partially crested. As with the preceding sub-family, the last spine of the outer row of the posterior tibiæ is wanting.

We have many representatives of the Œdipodinæ, and these are distributed by modern systematists among numerous genera. I have selected a few of the more common species of the Eastern United States as illustrations. These can be separated by the following table:

A. Wings with the disk yellow.
  B. Apical half of wing dusky.
    C. Dorsal aspect of head with a slight median carina, which is quite prominent in the well-marked depression on the vertex (central foveola). *Encoptŏlophus sŏrdidus.*
    CC. Dorsal aspect of head without median carina, or with merely an indication of one; central foveola less distinct. *Chortŏphaga viridifasciāta.*
  B. With a dark band across the wings. *Spharăgemon æquāle.*
AA. Wings with the disk black. *Dissosteira carolina.*
AAA. Wings with the disk red. *Hippĭscus discōideus.*

The Clouded Locust, *Encoptŏlophus sŏrdidus.*—This species is very common in the Eastern United States during the autumn. It abounds in meadows and pastures; and attracts attention by the crackling sound made by the males during flight. It is of a dirty-brown color, mottled with spots of a darker shade. It appears somewhat like the variety *infuscāta* of the following species, but it can be easily distinguished by the characters given in the table above. Size same as following species.

FIG. 93.—*Encoptolophus sordidus.*

* Œdipodinæ, Œdipoda: *oidos* (οιδος), a swelling; *pous* (πους), a foot.

The Green-striped Locust, *Chortŏphaga viridifasciāta*.—This is a very common species from Maine to Florida. There are two well-marked varieties. In one, the typical form, the head, thorax, and femora are green, and there is a broad green stripe on each wing-cover, extending from the horn to beyond the middle: this often includes two dusky spots on the edge. The second variety differs so much in appearance, that it was described by Harris as a distinct species under the specific name *infuscāta*. In this form the ground color is dusky brown. Intergrades occur, in which the head and thorax are of a reddish velvety brown. Length of male to end of abdomen 20 mm. (.8 inch), to tip of wings 25 mm. (1 inch); length of female to tip of wings about 30 mm. (1.4 inch).

The Barren-ground Locust, *Spharăgemon æquāle*.—This locust occurs throughout North America east of the Rocky Mountains. In the Northern United States it is found during the months of July and August on dry, barren hills, and on sandy plains. It is ash-gray in color, mottled with dusky brown and white; the face is whitish; the wing-covers are marked with dusky bands, and are semi-transparent at tip; the wings are traversed by a dark band just beyond the yellow disk. Length to tip of wings, male, 30 mm. (1.2 inch); female, 35 mm. (1.4 inch).

The Carolina Locust, *Dissostēria carolīna*.—Notwithstanding its specific name, this species is common throughout the United States and Canada. At the North it is the largest of our common locusts, but it is greatly surpassed in size by species found in the South. It abounds in the highways and in barren places. It takes flight readily, and the males stridulate while in the air. The color of this insect varies greatly, simulating that of the soil upon which it is found. It is usually of a pale yellowish or reddish brown, with small dusky spots. The wings are black, with a broad, yellow margin, which is covered with dusky spots at the tip. Length to tip of wings 35–45 mm. (1.4–1.8 inch).

Hippiscus discōideus.—This is the largest of our common representatives of the Œdipodinæ. It is a Southern species. I have, however, specimens from as far north as New Jersey. In color it is pale reddish or yellowish brown, with dark-brown spots; the wing-covers marked with strongly contrasting brown or blackish and white spots or bands, the anal area reddish. The disk of the wings is red. The body, especially of the female, is heavy, the thorax being both broad and deep. Length to tip of wings, male 40 mm. (1.6 inch); female, 55 mm. (2.2 inch).

Sub-family III.—EREMOBINÆ.*

This sub-family includes large, plump species, with the general appearance of members of the Œdipodinæ. They can be distinguished from the preceding sub-family by the presence of the terminal spine of the outer row of the posterior tibiæ (Fig. 94*a*); also by the presence of a rough plate on the side of the second abdominal segment (Fig. 95). The vertex is usually broad, flat, or concave, and

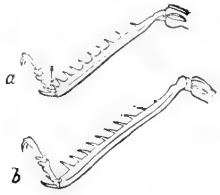

FIG. 94.—Legs of Locusts.

FIG. 95.—First abdominal segment of *Eremobia*.

strongly declivous; it is then suddenly narrowed and falls off vertically to the plain of the antennæ. In this place it forms a part apparently of the frontal costa, from which it is separated anatomically by a little transverse ridge. Below this ridge lies the middle ocellus. The eyes are relatively small, and widely separated by the broad vertex.

This sub-family is represented in our fauna by *Eremŏbia măgna* from Arizona.

Sub-family IV.—ACRIDINÆ.

Of the series of sub-families of Locusts in which the prosternum is armed, representatives of but two have as yet been discovered in our fauna. To the first of these, the Acridinæ, belong some of our most common and at the same time some of the most important species. In this sub-family the head is short, and is rounded at the union of the vertex and front. The front is slightly receding. The antennæ are filiform; and the terminal spine of the outer row of the posterior tibiæ is usually wanting.

This sub-family is represented by many forms in this country. Only those species that are most likely to attract attention are mentioned below. These can be determined generically by means of the following table:

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* Eremobīnæ, Erimōbia: *eremos* (ἔρημος), a desert; bioö (βιόω), to live.

A. Wings as long as or longer than the abdomen.
  B. Pronotum sloping from the median carina; lateral carinæ wanting; extremity of abdomen in males not swollen. 1. ACRIDIUM.
  BB. Pronotum somewhat flattened above; lateral margins angular; extremity of abdomen in the males much swollen. 4. MELANOPLUS.
AA. Wings of adult shorter than the abdomen or wanting.
  B. Prosternal spine prominent.
    C. Antennæ tapering to the tip; and with the segments very distinct. 2. DICTYOPHORUS.
    CC. Antennæ thread-like, of nearly the same thickness throughout; segments less distinct. 3. PEZOTETTIX.
  BB. Prosternal spine slightly developed. 5. BRACHYSTOLA.

1. *Acrĭdium.*—The most common representatives of this genus in the Eastern U. S. are *A. alutāccum* and *A. rubiginōsum.* In the Southern States the most conspicuous species is *A. americānum.*

The Leather-colored Locust, *Acrĭdium alutāceum.*—This locust is dirty brownish yellow, with a paler stripe on the top of the head and thorax; the wing-covers are semi-transparent, with irregular pale-brownish spots, and with the sutural margins yellowish. Posterior margin of each abdominal segment with a ring of black dots. The wing-covers are longer than the abdomen. Length of body to end of abdomen, female 43–50 mm. (1.7–2 in.), male 31 mm. (1.24 in.).

The Rusty Locust, *Acrĭdium rubiginōsum.*—The color of this species is light rust-red; the wing-covers are opaque, rather paler on the overlapping portion than elsewhere, and sometimes with dim spots, but usually without them. The wing-covers are about as long as the abdomen. Length of female 35–40 mm. (.4–1.6 in.); males much smaller.

The American Locust, *Acrĭdium americānum.*—This magnificent

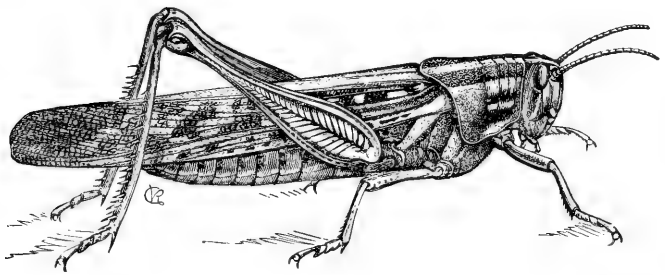

FIG. 96.—*Acridium americanum.* (From Riley.)

species occurs in the Southern States. It can be easily recognized from Fig. 96, which represents its natural size. This locust some-

times assumes the migratory habit, and is sometimes injurious to agriculture.

2. *Dictyŏphorus.*—This genus is represented by a very large and clumsy locust, which occurs in the southern part of our country, *D. reticulātus.* The adult is yellow and black; the tegmina and wings are shorter than the abdomen; the base and disk of the wings are red, with the outer margin black. Length of body in female about 60 mm. (2.4 in.), in male 50 mm. (2 in.). The nymphs of this species differ remarkably from the perfect insect, being of a very deep metallic bronze-green color approaching black, marked with yellow, deepening into red in spots, or wholly with blood-red; this is most conspicuous in a slender dorsal stripe the whole length of the creature, and on the hinder edge of the pronotum. I found these nymphs very abundant in May at Jacksonville, Fla.

3. *Pezotĕttix.*—To the genus Pezotettix belong a considerable number of short-winged locusts, of medium or small size. More than forty species have been found in the United States, but nearly all of these are from the Far West or from the South. The members of this genus, according to Brunner, with but few exceptions, prefer cool and shady localities, and hence are often found among or near rocks, on mountain slopes, in clearings or on the outskirts of timber belts, and in meadows.

The only species of Pezotettix that has been taken at Ithaca in considerable numbers, *P. Scŭddĕri,* occurs among scattered trees, on the crests and slopes of our highest hills. This species can be easily recognized by its close resemblance in form and appearance to the Common Red-legged Locust, *Melănoplus fēmur-rūbrum.* The only conspicuous difference is in the organs of flight: in *P. Scuddĕri* the wing-covers do not extend beyond the second abdominal segment.

In *Pezotĕttix glaciālis* the wings and wing-covers are wanting. This species inhabits the mountains of New England; it has also been taken at Ithaca, N. Y.

Pezotĕttix pĭctus is the brightest colored of all our locusts. It is bluish green, with bright red and yellow markings, and is found on the plains sloping eastward from the Rocky Mountains.

4. *Melănoplus.*—We have many species of locusts, which belong to this genus. Some of them are among the most common and most destructive members of the family Acridiidæ. Much has been written concerning them; but as most writers have believed that they belong to the genus Caloptenus, it will be necessary to

look under that head in the older works for descriptions of them.* The following table will aid in determining the males of the species mentioned below; as a rule there will be but little, if any, trouble in assorting the females after the males are determined.

A. Apex of last abdominal segment of male distinctly notched.
  B. Length of body to tip of wing-covers 29–35 mm. (1.16–1.4 inches). M. SPRETUS.
  BB. Length of body to tip of wing-covers 23–26 mm. (0.9–1.04 inches). M. ATLANTIS.
AA. Apex of last abdominal segment of male entire or most obscurely notched.
  B. Anal cerci enlarged at apex. M. FEMORATUS.
  BB. Anal cerci tapering.
    C. Species of medium size; anal cerci much narrowed, but without a notch. M. FEMUR-RUBRUM.
    CC. Species of large size; anal cerci suddenly narrowed, making a prominent right-angled notch on lower side. M. DIFFERENTIALIS.

The Rocky Mountain Locust or Western Grasshopper, *Melănoplus sprētus*.—The most terrible of insect scourges that this country has known have been the invasions of this species. Large areas of

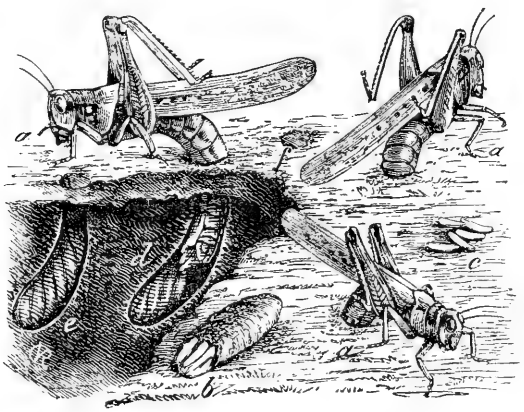

FIG. 97.—Egg-laying of the Rocky Mountain Locust. *a*, *a*, *a*, female in different positions, ovipositing; *b*, egg-pod extracted from the ground, with the end broken open; *c*, a few eggs lying loose on the ground; *de* shows the earth partially removed, to illustrate an egg-mass already in place, and one being placed; *f* shows where such a mass has been covered up. (From Riley.)

country have been devastated, and the inhabitants reduced to a state of starvation. The cause of all this suffering is not a large insect. It is represented natural size by Fig. 97. It measures to

* For a statement of the reasons for the adoption of the name Melanoplus, see paper by S. H. Scudder, Proc. Boston Soc. Nat. Hist., Vol. XIX. p. 281.

the tip of its wing-covers 29–35 mm. (1.16–1.4 inches), and resembles very closely our common Red-legged Locust, the most abundant of all our species. It can easily be distinguished from this species by the greater length of the wings, which extend about one third of their length beyond the tip of the abdomen, and by the fact that the apex of the last abdominal segment in the males is distinctly notched.

The permanent home or breeding grounds of this species is in the high dry lands on the eastern slope of the Rocky Mountains, extending from the southern limit of the true forests in British America south through Montana, Wyoming, the western part of Dakota, and the Parks of Colorado. There are also regions in which the species exists permanently west of the Rocky Mountains in Idaho and Utah.

When the food of this insect becomes scarce in its mountain home, it migrates to lower and more fertile regions. Its long wings enable it to travel great distances; and thus the larger part of the region west of the Mississippi River is liable to be invaded by it. Fortunately, the species cannot long survive in the low, moist regions of the valleys. Although the hordes of locusts which reach these sections retain their vigor, and frequently consume every bit of green vegetation, the young, which hatch from the eggs that they lay, perish before reaching maturity. In this way, the invaded region is freed from the pest until it is stocked again by another incursion. There is, however, a large section of country lying immediately east of the great area indicated above as the permanent home of this species, which it frequently invades, and in which it can perpetuate itself for several years, but from which it in time disappears. This sub-permanent region, as it has been termed, extends east in British America so as to include nearly one third of Manitoba; and, in the United States, it embraces nearly the whole of Dakota, the western half of Nebraska, and the north-east fourth of Colorado.

The temporary region, or that only periodically visited and from which the species generally disappears within a year, extends east and south so as to include more than half of Minnesota and Iowa, the western tier of counties of Missouri, the whole of Kansas and Indian Territory, and the greater part of Texas. The country lying east of the section thus indicated has never been invaded by this locust, and there is no probability that it will ever be reached by it.

The United States Entomological Commission has published

three large volumes regarding this insect. The student is referred to them for a detailed account of it.

The Lesser Locust, *Melănoplus atlăntis*.—This is a common species, which is very closely allied to the Rocky Mountain Locust. It can be distinguished, however, by its smaller size, as indicated above, and by its shorter wings. The specific name is an inappropriate one; for the species occurs, throughout at least the northern part of our country, from the Atlantic to the Pacific.

The Red-legged Locust, *Melănoplus femur-rubrum*.—This is the most familiar member of the family Acridiidæ throughout the United States, except where *M. sprētus* occurs. It is more abundant than any other locust east of the Mississippi; it is this and the preceding species, which is usually confounded with it, that ravage our meadows and pastures more than all other species combined. The female is represented natural size by Fig. 98.

FIG. 98.—*Melanoplus femur-rubrum.*

Melănoplus femorātus.—This species also extends from the Atlantic to the Pacific. It is the largest representative of the genus that occurs in the Eastern States. It is marked with a yellowish stripe, extending along each side from the upper angle of the eye to the tip of the elytra (Fig. 99). The length of the body to the tip of the abdomen varies from 25 mm. (1 inch) to 40 mm. (1.6 inches). This species has been confounded in most of our works on Ento-

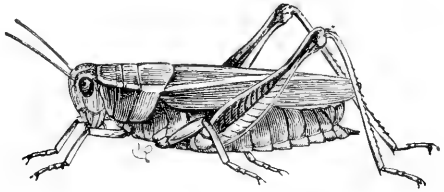

FIG. 99.—*M. femoratus.* (From Riley.)

FIG. 100.—*M. differentialis.* (From Riley.)

mology with *M. bivittatus*, a closely allied species, which occurs in the interior.

M. differentiālis.—This species is slightly larger than the preceding; it lacks the prominent yellow stripes, and is confined to the central portion of the United States (Fig. 100).

5. *Brachỹstola.*—This genus is represented by the "Lubber Grasshopper" or Clumsy Locust of the plains, *B. măgna.* This insect is confined to the central portion of North America, and it can be readily recognized by the accompanying figure (Fig. 101).

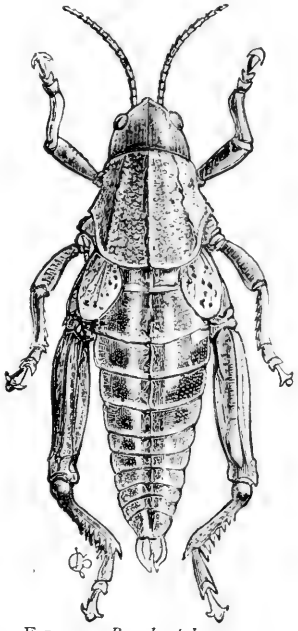

FIG. 101.—*Brachystola magna.* (From Riley.)

Sub-Family V.—OPOMALINÆ.*

This sub-family is closely related to the Acrididæ; and the members of it resemble that sub-family in having the prosternum armed. The Opomalinæ are distinguished by the vertex extending horizontally in front of the eyes, by the strongly receding front, and by the short fore and middle femora. The antennæ are usually more or less flattened; and the terminal spine of the outer row of the posterior tibiæ is never wanting.

Several genera of this sub-family are represented in this country. The species are more common in the South and West than in the

FIG. 102.—*Leptysma marginicolle.*

Northeast. Fig. 102 represents *Leptỹsma marginicŏlle;* this species occurs in Florida, and will serve as an illustration of the sub-family.

Sub-Family VI.—TETTIGINÆ.†

The *Tettiginæ* includes small locusts of very unusual form. The most striking character of the sub-family is the shape of the pro-

* Opomalĭnæ, Opŏmala: *ops* (ὤψ), appearance; *omalos* (ὁμαλός), plane.
† Tettigĭnæ, Tĕttix: *tettix* (τέττιξ), the Greek name for these insects.

notum. This is prolonged backwards over the abdomen to or beyond its extremity (Fig. 103). The head is deeply set in the pronotum, and the prosternum is expanded into a broad border which partially envelops the mouth like a muffler. The antennæ are very slender and short. The tegmina are rudimentary, being in the form of small, rough scales, while the wings are usually well developed. These locusts differ, also, from all others in having no pulvilli between the claws of the tarsi.

FIG. 103.—*Tettix.*

The Tettiginæ are commonly found in low, wet places, and on the borders of streams. Their colors are usually dark, and are often protective, closely resembling that of the soil upon which the insects occur. They are very active, and possess great leaping powers.

Three genera of this sub-family are represented in this country. These can be separated by the following table:

A. Pronotum arched roundly, antennæ 12-jointed.	BATRACHĬDEA.
AA. Pronotum nearly or quite horizontal.	
B. Antennæ 13- or 14-jointed.	TETTIX.
BB. Antennæ 22-jointed.	TETTIGĬDEA.

Family VI.—LOCUSTIDÆ.*

(*Long-horned Grasshoppers and Katydids.*)

The members of this family are easily recognized. They differ from the Acrididæ in the great length of the antennæ, which are longer than the body. From the Gryllidæ, which they resemble in the length of the antennæ, they are distinguished by the form of the ovipositor, which is compressed and sword-shaped; and by the four-jointed tarsi. As with the Crickets, the tegmina of the males are furnished with a musical apparatus. But this occupies a much smaller part of the tegmina than with the Crickets. Excepting this small area, the anal, the tegmina, when at rest, are vertical.

The name of this family, as is the custom, is derived from the name of its typical genus, *Locusta*. But the insects which are rightly termed in popular language Locusts belong to the preceding family, the Acrididæ. That is, to that family belong the insects spoken of in the Bible, and in modern European works, as locusts. In this country, unfortunately, the term grasshopper has been used to include both the true grasshoppers, *i.e.*, the Locustidæ, and the true locusts: while the term locust has been applied to an insect of an-

* Locŭstidæ, Locŭsta: *Locusta*, a locust.

other order, the *Cicada*. In order to avoid confusion, I have referred to the members of the Locustidæ and the Acridiidæ as Long-horned Grasshoppers and Short-horned Grasshoppers respectively. It is better, however, to call the former Grasshoppers, and the latter Locusts. This last term should never be applied to the well-known insect which appears once in seventeen years; this is rightly called the Periodical Cicada.

Representatives of each of the more common genera of the Northeastern United States are mentioned below. These genera can be separated by the following table:*

A. Wingless, or with rudimentary wings and wing-covers.
  B. Pronotum not extended over the meso- and metanotum. 1. CEUTHOPHILUS.
  BB. Pronotum extended over meso- and metanotum. 9. THYREONOTUS.
AA. Winged.
  B. Tegmina expanded in the middle.
    C. Tegmina much broadened in the middle, concave. 5. CYRTOPHYLLUS.
    CC. Tegmina somewhat broadened in the middle, not concave.
      D. Ovipositor very small. 7. MICROCENTRUM.
      DD. Ovipositor of medium size. 6. AMBLYCORPHYA.
  BB. Tegmina not expanded in the middle.
    C. Vertex of the head with a conical projection forwards. 4. CONOCEPHALUS.
    CC. Vertex of the head without a conical projection.
      D. Ovipositor straight, or very nearly so; insect small. 2. XIPHIDIUM.
      DD. Ovipositor curved; insect large.
        E. Ovipositor curved sharply upwards. 8. SCUDDERIA.
        EE. Ovipositor sword-shaped. 3. ORCHELIMUM.

In order to facilitate the study of the Locustarians, our common genera can be arranged in four groups; namely, the Cricket-like Grasshoppers, the Meadow Grasshoppers, the Katydids, and the Shield-backed Grasshoppers.

I. *The Cricket-like Grasshoppers.*

1. *Ceuthŏphilus.*—To the genus Ceuthophilus belong certain wingless grasshoppers, which bear some resemblance in form to crickets (Fig. 104). They have a short, thick body and remarkably stout hind femora, like a cricket, but are entirely destitute of tegmina and wings. All the species in our collection are either of a pale brown or dirty white color and more or less mottled with either

* After S. H. Scudder, Boston Journal Natural History, Vol. VII. p. 414.

lighter or darker shades. These insects are found under stones and rubbish in woods. Very closely allied to them are the "Cave-crickets." These belong to the genus *Hadenœcus*. *H. cavernārum* inhabits the caves of this country; it has very long legs and antennæ, is colorless and blind.

FIG. 104.—*Ceuthophilus*.

II. *The Meadow Grasshoppers.*

2. *Xiphĭdium.*—From the middle of the summer to the autumn there may be found upon the grass in our meadows and moist pastures many light-green grasshoppers of various sizes. These, on account of the situations in which they are usually found, are termed the meadow grasshoppers. A large proportion of the species belong to the genus *Xiphidium*. This genus comprises the smaller of our common species. The members of it do not have the head furnished with a conical projection, and the ovipositor of the females is straight and sword-shaped (Fig. 105). We have three common species in the Middle States. In one of them, *X. fasciātum*, the tegmina and wings are long, extending far beyond the tip of the abdomen. In each of the other species the tegmina and wings are much shortened. *X. ĕnsifer* is characterized by the great length of the ovipositor, which is longer than the rest of the body; while the ovipositor of *X. brevipĕnnis* is a little shorter than the hind femora.

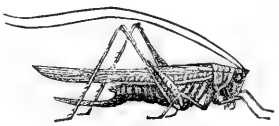

FIG. 105.—*Xiphidium*.

3. *Orchelĭmum.*—These insects differ from the other common meadow grasshoppers in having the ovipositor curved. Our most common species is *O. vulgāre*. This species measures from the vertex of the head to the end of the abdomen 18 mm. (0.7 inch), or to the tip of the wing-covers 25 mm. (1 inch). The brown line on the dorsal aspect of the head and thorax does not extend down upon the front of the head; in the males there are two short black dashes on each of the tegmina; the four form the angles of a square, inclosing the musical apparatus. The wings equal the tegmina in length or are a little shorter. Another common species is *O. glabĕrrimum*. This has the dorsal band and the musical apparatus of the males bordered with black, and the ovipositor slightly expanded in the middle. *O. agĭle* has a narrow dark streak down the middle of the

front of the head. *O. concĭnnum* is found in Massachusetts; this also has a dark streak extending down the front to the labrum, but it expands broadly in the middle of the face.

4. *Conocĕphalus.*—This genus includes the largest of our meadow grasshoppers. It differs from the genera already named in having the head prolonged into a cone-shaped projection. The species are found in trees as well as in grass, having a strong resemblance to the katydids both in appearance and habits. The most common species throughout the eastern part of our country is *C. ĕnsiger.* Both sexes have very long wings; and the ovipositor of the female is remarkable for its length. The length of the body from the tip of the head to the end of the abdomen is 30 mm. (1.2 inches), while the distance from the tip of the head to the end of the wings or ovipositor is twice that amount. Two distinct forms of this species occur; one is pea-green, and the other is of a brownish straw color. *C. robŭstus* is a stouter species than the preceding, and has a shorter ovipositor. This also exhibits dimorphism, being either pea-green or brown in color. The specimens in our collection are from Cape Cod and New Jersey. I have not seen any notice of its occurring in the interior.

III. *The Katydids.*

The song of the Katydids is known to every lover of Nature that lives in the country. But the insects themselves are much less familiar. Only the careful and patient observer succeeds in tracing the well-known and oft-repeated "Katy-did, Katy-did" or "Katy-she-did" to its source. The successful ones are rewarded by the sight of a beautiful insect. The Katydids, of which there are in the United States at least a dozen species, are large green grasshoppers with broad, leaf-like wing-covers and long, delicate antennæ. They differ from the meadow grasshoppers in being arboreal. They are protected from observation by the color and shape of their tegmina, which resemble the leaves of trees. Although they feed upon the foliage of the trees which they inhabit, it is rare that they are sufficiently abundant to be of economic importance. The only locality in which I have known them to be injurious is Florida, where they infest orange-trees.

Our species represent four genera. These can be separated by the table given above.

5. *Cyrtŏphyllus.*—The true Katydid, the one whose song suggested the popular name, is *Cyrtŏphyllus concāvus.* This has been

named the Broad-winged Katydid; it occurs throughout the Central and Eastern States. A closely allied species, *C. perspicillātus*, occurs in the South. These differ from other Katydids in having the wings shorter than the tegmina, and in having the tegmina very convex, so that the insects have an inflated appearance, instead of a narrow, compressed form, as is usually the case. The Southern species has shorter tegmina, more robust legs, and the musical apparatus of the male is slightly broader than in the Northern form.

6. *Amblycŏrypha.*—We have at least four species that pertain to this genus. The Round-winged Katydid, *A. rotundifōlia*, is very common throughout the Northern States and Canada. It is a small species; the length of the body is 20 mm. (0.8 inch), and of the tegmina 25 mm. (1 inch). The tegmina are wide for their length, as indicated by the specific name. The ovipositor is quite broad, much curved, and roughly serrated. The Oblong-winged Katydid, *A. oblongifōlia*, occurs in the same region as the preceding species; it is larger, has longer tegmina, and the ovipositor is less serrate and less curved.* The Tailed Katydid, *A. caudāta*, occurs in the South; it is still larger than the preceding, and has a very long ovipositor. The length of the body is 25 mm. (1 inch), of the tegmina 37 mm. (1.5 inches), and of the ovipositor 20 mm. (0.8 inch). Uhler's Katydid, *A. Uhlĕrii*, is our smallest species; it is common in Maryland and about Washington.

7. *Microcĕntrum.*—The Angular-winged Katydid, *Microcĕntrum retinĕrvis*, is the commonest species in the Western and Southern States. It is especially abundant in Florida, where it often injures the foliage of young orange-trees. Its eggs, which are deposited in one or two rows upon twigs or the margin of leaves, frequently attract attention on account of their large size and the remarkable regularity of their arrangement. These are shown natural size on Plate III. The adult female and several nymphs are represented at the same place. Frequently the eggs of this species are infested by a Chalcid parasite, *Eupĕlmus mirābilis*, which is represented enlarged on the same plate (2, female; 2*a*, male). There is a closely allied Katydid, *M. affiliātum*, occurring throughout the Eastern United States, which is larger, and which differs in that the slightly hollowed front of the prothorax has a very small central tooth. This is a rarer species than the preceding.

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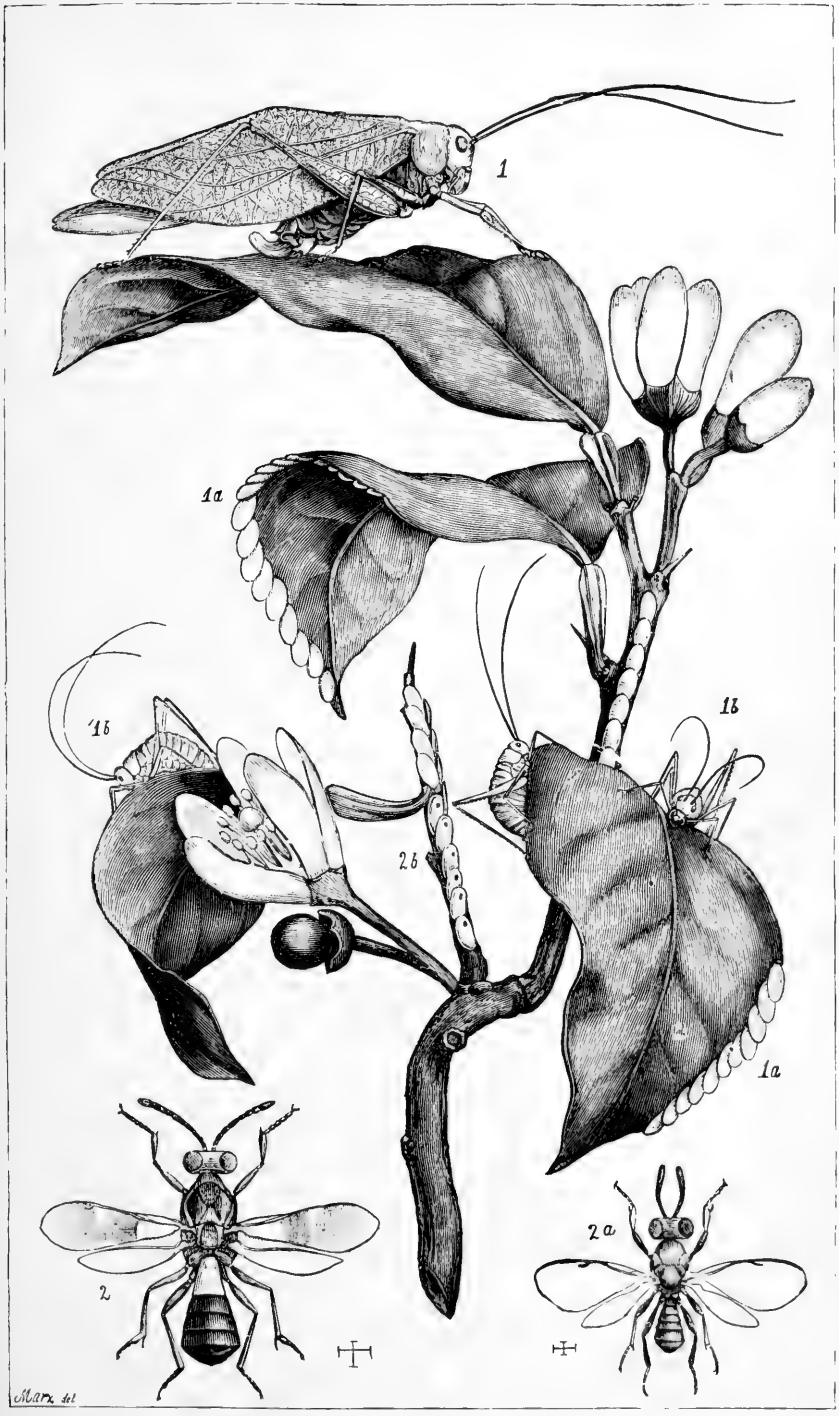
* Fig. 75 of Harris's "Insects Injurious to Vegetation" is of *A. rotundifolia*, and not of this species as indicated in the text.


1
1a
1b
1b
2b
1a
2
2a
Marx del.

8. *Scuddēria.*—The Narrow-winged Katydid, *Scuddēria curvicāūda,* is the common species of this genus. It is quite abundant in many parts of the country. The tegmina are long and narrow, hence the common name. The eggs of this species "are laid singly in the edges of leaves, between the upper and lower cuticles, and are so thin that they are not noticeable except when the leaf is held between one's self and the light. They swell very considerably, however, in the spring, before hatching." (Riley.)

IV. *The Shield-backed Grasshoppers.*

9. *Thyreonōtus.*—These are wingless, dull-colored grasshoppers which offer a striking appearance, owing to the great size of the pronotum. This segment is so enlarged as to extend back over the other two thoracic segments. The ovipositor of the female is also greatly developed, and is nearly straight. We have in the eastern half of the United States two widely-spread species. *T. dorsālis* has

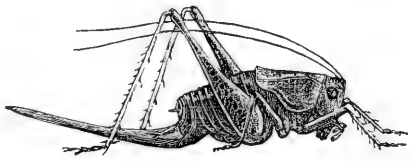


FIG. 106.—*Thyreonotus.*

the pronotum well rounded behind. In *T. pachÿmerus* (Fig. 106) it is nearly square. The hind legs and ovipositor are longer in *T. dorsalis* than in the other species.

In the region west of the Mississippi River are found wingless grasshoppers which are known as "Western crickets." These belong to the genus *Ănabrus.* This genus resembles *Thyreonotus* in the shield-like pronotum and the large size of the ovipositor, but differs in having the prosternum unarmed, while in the former genus there are two spines between the base of the front legs. Three species of *Anabrus* have been described. "*A. colorādus* is the smallest, and has the abdomen distinctly marked by transverse bands; *A. purpurăscens,* dark purplish brown, mottled with yellow; *A. sĭmplex,* dark shining brown. This species varies considerably in color, being found of every shade from light brownish yellow to almost entirely black; specimens are sometimes found that are partly yellow and partly black or dark purple." *A. simplex* is sometimes very destructive to crops.

Family VII.—Gryllidæ.*

(*Crickets.*)

The Crickets constitute the last of the three families embraced in the section Saltatoria. They agree with the members of the preceding family, the Locustidæ, in the possession of long, slender, delicately-tapering antennæ, and differ in the form of the tegmina, the number of segments in the tarsi, and the form of the ovipositor. The tegmina in the Gryllidæ are horizontal, with the outer portion bent abruptly downwards; the tarsi are three-jointed, except in *Œcanthus*, which has the hind tarsi four-jointed, and the ovipositor is usually long and spear-shaped.

With most species of crickets the two sexes differ greatly in appearance. The female has a long ovipositor, and the venation of the tegmina is simple, while the male has the veins upon the horizontal part of the tegmina so modified as to admit of their being used as a musical organ.

During the latter part of the summer and in the autumn, the air is filled with the cries of the crickets. With care it is easy to observe these little fiddlers calling their mates. The common field-crickets lurk in holes in the ground and under stones, or, emerging from these retreats, run through the grass in search of food. At the season indicated above, the male crickets spend much time at or near the entrance of their burrows, making their peculiar calls. So intent upon this are they, that by moving quietly one can approach sufficiently near to watch them carefully. And even when they are disturbed they retreat into their holes only for a short time, if all remains still. At night they can be observed by means of a lantern, as light does not disturb them. In order to understand the manner of making these calls, it is necessary to study the structure of the tegmina. In the male crickets these organs differ greatly

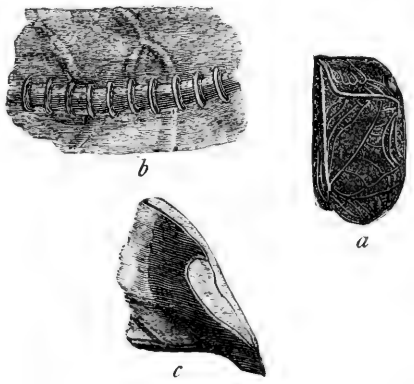


Fig. 107.—Tegmina of male *Gryllus*.

* Grȳllidæ, Grȳllus: *gryllus*, a cricket.

from the simple form seen in the females. In Fig. 107, *a* represents the tegmina of a male *Gryllus*. It will be seen that the large veins divide the wing into disk-like membranous spaces. If the principal vein, which extends diagonally across the base of the wing, be examined with a microscope, it will be seen to be furnished with transverse ridges like a file (Fig. 107, *b*). On the inner margin of the wing, a short distance towards the base from the end of the principal vein, there is a hardened portion which may be called the scraper. This is shown enlarged at *c* in the figure. Each tegmina is therefore provided with a file and scraper. When the cricket wishes to make his call, he elevates his tegmina at an angle of about forty-five degrees with the body; then holding them in such a position that the scraper of one rests upon the file of the other, he moves the tegmina back and forth laterally, so that the file and scraper rasp upon each other. This throws the tegmina into vibration, and produces the call.

The Gryllidæ is a comparatively small family, but the American species have not yet been monographed. The few genera which I have selected as illustrations, and which are our most common ones, can be separated by the following table:

A. Fore tibiæ broad, fitted for digging. (Fossorial Crickets.)
  B. Insect small; antennæ ten- to twelve-jointed. 1. TRIDACTYLUS.
  BB. Insect large; antennæ many-jointed. 2. GRYLLOTALPA.
AA. Fore tibiæ slender.
  B. Hind femora stoutish. (True Crickets.)
    C. Last segment of the maxillary palpi of the same length as the next to the last. 3. GRYLLUS.
    CC. Last segment of the maxillary palpi double the length of the next to the last. 4. NEMOBIUS.
  BB. Hind femora slender. (Tree-crickets.) 5. ŒCANTHUS.

The Fossorial Crickets.—We have two genera representing this group; they are commonly known as Mole-crickets. There are species belonging to the next group, the true crickets, which burrow in the ground; but the mole-crickets, as their common name indicates, are pre-eminently burrowers. The form of the body is that suited to this mode of life. The front tibiæ, especially, are fitted for digging. They are greatly broadened, and shaped somewhat like a hand, or the feet of a mole. *Gryllotălpa* is the better known of these two genera, this is doubtless owing to the large size of the species. The Northern Mole-cricket, *Gryllotălpa borcālis*, inhabits nearly the whole of the United States east of the great plains, from Louisiana to Massachusetts. It is not a common insect, but occasionally it is found in great numbers in a limited locality. It can be

easily recognized by the accompanying figure, which represents the insect natural size. They make burrows in moist places from six to eight inches below the surface of the ground, and feed upon the tender roots of various plants. In Europe, where mole-crickets are more abundant, they are frequently serious pests in cultivated fields; and in the West Indies there is a species which is very destructive to sugar-cane. The species of *Tridăctylus* resemble *Gryllotalpa* somewhat in form, but are very much smaller; our species are all less than 10 mm. (0.4 inch) in length. They also resemble the large mole-crickets in habits, burrowing in similar places. But they differ in having their hind legs formed for leaping, and are able to jump as well as the true crickets. At Ithaca we find Tridactylus very local in its distribution. A large number of specimens have been taken from a small spot on the margin of one of our streams, but a most careful search has failed to reveal its presence elsewhere in our region.

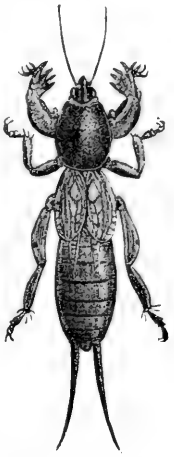


FIG. 108. — *Gryllotalpa borealis.*

The True Crickets.—The true crickets abound everywhere, in pastures, meadows, and gardens; and certain species enter our dwellings. They are chiefly solitary, nocturnal insects; yet many can be seen in the fields in the daytime. They usually feed upon plants, but are sometimes predaceous. The eggs are laid in the autumn, usually in the ground, and are hatched in the following summer. The greater part of the old crickets die on the approach of winter; but a few survive the cold season. The greater part of the species of our true crickets are included in the two genera *Gryllus* and *Nemōbius*. To the former genus belongs our larger species. The two larger of our species are *Gryllus luctuōsus* and *Gryllus abbreviātus* (Fig. 108*a*). The species of the genus Nemobius are much smaller than Gryllus, and are characterized by the greater length of the last segment of the maxillary palpi. The most common species, and one that is very abundant in our fields during the latter part of summer and autumn, is *Nemobius vittatus*.

FIG. 108*a*.—*Gryllus abbreviatus.*

The Tree-crickets.—Our common Tree-crickets belong to the genus *Œcănthus*. The most abundant species is the Snowy Tree-cricket, *Œcănthus nĭveus* (Fig. 109). This is a delicate greenish-white insect. The male is represented in the figure. The closely-folded wings can be seen through the transparent tegmina. The wings vary greatly in length; sometimes they are longer than the tegmina, and sometimes not as long. In the females the tegmina are wrapped closely about the body,

FIG. 109.—*Œcanthus niveus*, male.

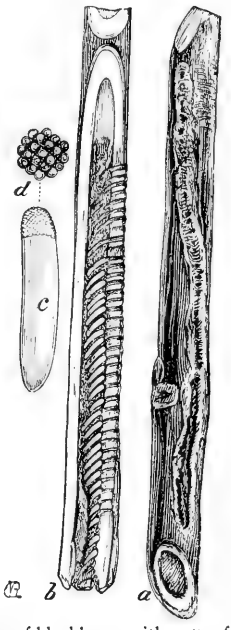


FIG. 110.—Stem of blackberry with eggs of *Œcanthus niveus*. *c*, egg enlarged; *d*, ornamentation of egg (From Riley.)

making the insect much narrower than its mate. The female lays her eggs in a longitudinal series in the twigs or canes of various plants (Fig. 110). She selects the raspberry more often than any other plant; and as that portion of the cane beyond the incisions made for the eggs usually dies, it often happens that these crickets materially injure the plants. In such cases the dead canes should be cut out and burned early in the spring before the eggs hatch.

CHAPTER VII.

Order IV.—PHYSOPODA.*

(*Thrips.*)

The members of this order have four wings; these are similar in form, long, narrow, membranous, not folded, with but few or no veins, and only rarely with cross-veins; they are fringed with long hairs; and are laid horizontally along the back when at rest. The metamorphosis is incomplete. The mouth-parts are probably used chiefly for sucking; they are intermediate in form between those of the sucking and those of the biting insects; the mandibles are bristle-like; the maxillæ are triangular, flat, and furnished with palpi; and the labial palpi are also present. The tarsi are two-jointed, bladder-like at tip, and without claws.

These are insects of minute size, rarely exceeding 2 mm. or 3 mm. in length. They can, however, be obtained easily from various flowers, especially those of the daisy and clover. Ordinarily, it is only necessary to pull apart one of these flowers to find several specimens of Thrips. They are in many cases very active insects, leaping or taking flight with great agility. In case they do not leap or take flight when alarmed, they are apt to run about and at the same time turn up the end of the abdomen in a threatening manner, as if to sting. In this respect they resemble the Rove-beetles.

Fig. 111.—*Thrips.*

The body is long (Fig. 111). The head is narrower than the thorax, without any distinct neck; the eyes are large, with conspicuous ocelli; there are also usually three simple eyes. The ventral side of the head is prolonged into a conical beak, which extends beneath the prosternum. The form of the mouth-parts can only be made out by dissection and the use of high powers of the microscope. Fig. 112 represents the mouth-parts of one of our common

* Physŏpoda: *physao* (φυσάω), to blow up; *pous* (πούς), a foot.

species. The mandibles are long, bristle-like, curved, and somewhat flattened at the base; the maxillae are broad at the base, and taper to a point; they are furnished with well-developed palpi; the labial palpi are distinct, but less conspicuous; the labrum, in the form figured, is furnished with a curious appendage at its tip; and the labium is deeply emarginate. The three thoracic segments are well developed. The wings are laid horizontally on the back when not in use; they are very narrow, but are fringed with long hairs, which, diverging in flight, compensate for the smallness of the membrane. This fringing of the wings suggested the name *Thysanŏptera*, by which the order is designated in many entomological works. In some species the wings are wanting. The legs are well developed, but are furnished with very peculiar tarsi; these are two-jointed, and are bladder-like at the tip. It is this character that suggested the name *Physopoda*. The abdomen is more or less spindle-form; it is terminated in some genera by a long, slender segment; in others, the females are furnished with a four-valved ovipositor, which lies in a groove on the ventral aspect of the abdomen.

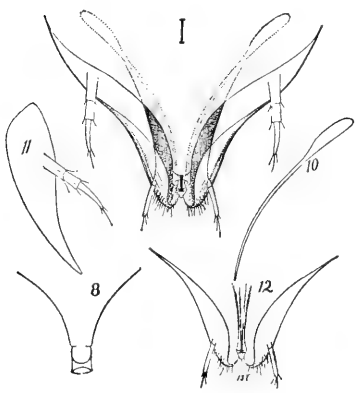


FIG. 112.—Mouth-parts of *Thrips*. (Drawn by J. M. Stedman, under the author's direction.) 8, labrum; 10, mandible; 11, maxilla; 12, labium.

"The larva resembles the perfect insect, but has a softer body, with the mesothorax and metathorax distinct; the mouth is like that of the adult; the antennæ and legs are shorter; there are no simple eyes; and the compound ones are replaced by conglomerate eyes. The pupa resembles the perfect insect, but the articulations of the limbs are obscured by a film, and the wings inclosed in short fixed sheaths. The antennæ are turned back on the head, and the insect, though it moves about, is much more sluggish than in the other states." (Haliday.)

The different species of Thrips vary greatly in habits, some being injurious to vegetation, while others are carnivorous. It should be borne in mind that the insect commonly called *The Thrips*, that infests the leaves of grape, is not a member of this order, but one of the Leaf-hoppers (family Jassidæ of the order Hemiptera). The

misapplication of the name Thrips to this insect is often the cause of confusion.

In taking up the Physopoda, it seems very probable that we return again to near the foot of the insect series as represented by living forms. This is indicated by the Campodea-like form of the body, the presence of rudimentary abdominal legs in a European species, and the Podura-like habit of jumping of many forms.

These insects have been placed in various positions. But the structure of the mouth, and the character of the wings, throw them out of any of the accepted orders. And now the majority of entomologists agree in assigning them the rank of a distinct order. As to the position of this order, it seems to me that it is the lowest living representative of one of the lines of development of winged insects, of which line the Hemiptera is the culmination.

The Physopoda has not been thoroughly studied. The most important paper on the insects of this order is by A. H. Haliday. This was published in the Entomological Magazine for 1836. It is entitled *An Epitome of the British Genera, in the Order Thysanoptera, with Indications of a few of the Species.* Although this article was published more than a half century ago, and was intended only to include the British genera, it is the most complete account we have of the order. The following classification is compiled from it:

Sub-Order I.—TUBULIFERA.*

This sub-order is characterized by the absence of a borer in the females, and by having the last abdominal segment in both sexes elongated, narrow, and tubular. The maxillary palpi are two-jointed, with the first segment very short; the wings are without veins; the two pairs are of the same structure; they are naked, except the marginal fringe of hairs; and when at rest, they are crossed so as to lie upon each other upon the abdomen.

This sub-order includes a single family, the *Tubuliferidæ.* And only a single genus, *Phlœothrips*, representing this family, was described by Haliday.

Phlœothrips.—Here belong the more common of the black thrips which abound in the flowers of clover and daisy; they are also found, as their name indicates, under the bark of trees.

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* Tubulifera: *tubulus*, a small tube; *fero*, to bear.

Sub-Order II.—TEREBRANTIA.*

This sub-order is characterized by the presence in the female of a four-valved borer. The maxillary palpi are three-jointed; the two pairs of wings differ somewhat in structure; the first pair is somewhat longer, and wider, and usually also thicker; sometimes they are almost horny; both pairs are clothed with numerous very fine hairs; the front wings have two parallel veins, the hind wings a single vein or none; the veins of the wings usually bear conspicuous spines; the wings, when not in use, are folded parallel to each other on the abdomen.

The members of this sub-order are much more agile than those of the preceding. They run rapidly, and spring, by bending under the tip of the abdomen and suddenly straightening it out.

The Terebrantia includes two families; these can be separated as follows:

A. Females with borer curved downwards.	Fam. II.—STENOPTERIDÆ.
AA. Females with borer curved upwards.	Fam. III.—COLEOPTRATIDÆ.

Family II.—STENOPTERIDÆ.†

In the Stenopteridæ the wings are narrow and are furnished with one or two longitudinal veins; but there are no cross-veins. The longitudinal veins are usually fringed with spines. There are two or three small indistinct segments at the end of the antennæ. And, as stated above, the ovipositor of the female is curved downwards. This family includes the greater number of the members of the order. The following table will aid in determining the genera:

A. Body above netted with elevated lines.	1. HELIOTHRIPS.
AA. Body smooth.	
B. Abdomen clothed with silky hairs.	2. SERICOTHRIPS.
BB. Body glabrous.	
C. Prothorax produced in front and narrowed.	3. CHIROTHRIPS.
CC. Prothorax not narrowed.	
D. Last segment of abdomen armed with paired spines in the female; male wingless.	4. LIMOTHRIPS.
DD. Last segment unarmed.	
E. The last two segments of the antennæ shorter than the sixth segment.	5. THRIPS.
EE. The last two segments of the antennæ longer than the sixth segment.	6. BELOTHRIPS.

* Terebrăntia: *terebro*, to bore through.

† Stenoptĕridæ: *stenos* (στενός), narrow; *pteron* (πτερόν), a wing.

The most abundant members of this family pertain to the genus Limothrips. There is a light yellow species which swarms in the flowers of clover and daisies. Another common species I have designated, in my "Notes on Entomology," as The Grass-eating Thrips, *Limothrips poaphagus*. The injury caused by this pest often attracts attention, although the insect itself is rarely observed. It infests timothy and June-grass, causing the head to turn yellow and die before maturing. These dead heads are very abundant every year. By pulling the head from its sheath, the stalk will be found to be shrunken in the tender part just above the joint, where the juice has been sucked from it; and in this place, if the examination be made soon after the turning yellow of the head, the insect can also be found. The adult female is light yellow in color, measures from 1 mm. to 1⅓ mm. (0.04 inch to 0.05 inch) in length, and is remarkable in lacking the long spines on the veins of the wings.

Family III.—Coleoptratidæ.*

This family is characterized by having the ovipositor of the female curved upwards. The front wings are broader than in the preceding family, and are furnished with both longitudinal and cross veins. The following-named genera are indicated by Haliday:

A. Antennæ with nine distinct segments. 1. Melanthrips.

AA. Antennæ apparently five-jointed, the last four segments being minute and compact.

B. Body somewhat flattened; mesothorax and metathorax broad; front wings without fringe on costal border, and with four cross veins; males with lateral abdominal appendages. 2. Coleothrips.

BB. Body cylindrical; mesothorax and metathorax constricted, wings rudimentary. 3. Æolothrips.

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* Coleoptratidæ: *coleopteros* (κολεόπτερος), sheath-winged.

CHAPTER VIII.

Order V.—HEMIPTERA.*

(*Bugs, Plant-lice, Bark-lice, et al.*)

The members of this order have four wings; in one sub-order the first pair of wings are of the same thickness throughout, and usually slope at the sides of the body; in another sub-order the first pair of wings are thickened at the base, with thinner extremities which overlap on the back. The mouth-parts are formed for sucking. The metamorphosis is incomplete.

The Hemiptera comprises the insects which are properly called bugs. This term is commonly applied to any thing that creeps or crawls; but the entomologist always refers to a member of this order when he speaks of a bug. In addition to the general term bug, the representatives of some of the families are known by special names, as plant-lice, bark-lice, leaf-hoppers, water-boatmen, and others. The order is a very important one; it includes many species injurious to vegetation, which often occur in such great numbers as to destroy the plants infested. On the other hand, some of the species are ranked among beneficial insects on account of their carnivorous habits; while still others, as the cochineal and lac insects, furnish us with useful products.

The name Hemiptera was suggested by the form of the front wings in the sub-order Heteroptera; here the basal half of these organs is thickened so as to resemble the elytra of beetles, only the terminal half being wing-like. The second pair of wings are membranous, and are folded beneath the first pair. On this account, the latter are often termed wing-covers; they are also termed *hemelytra*, a word suggested by their structure.

The wing-covers of the Heteroptera present characters much used in classification; and consequently special names have been applied to the different parts. The thickened basal portion is

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* Hemĭptera: *hemi-* (ἡμι-), half; *pteron* (πτερόν), a wing.

composed of two pieces joined together at their sides; one of these is narrow, and is the part next to the scutellum when the wings are closed (Fig. 113, *Cl*); this is distinguished as the *clāvus:* the other broader part is the *cōrium* (Fig. 113, *Co*). The terminal portion of the wing-cover is designated as the *membrane* (Fig. 113, *M*). In certain families, a triangular portion of the terminal part of the corium is separated as a distinct piece (Fig. 113, *Cu*); this is the *cūneus*. In certain other cases, a narrow piece on the costal margin of the corium is separated (Fig. 113, *E*); this is the *embōlium*. Both pairs of wings in the Homoptera and Heteroptera are furnished with veins; but it is not necessary for the purposes of this work to discuss here the nomenclature of these veins.

FIG. 113.—Diagram of wing-cover.

The mouth-parts are formed for piercing and sucking. Without dissection, they usually appear as a slender jointed beak, arising at the base of a shorter pointed labrum. This beak consists of four bristles inclosed in a fleshy, jointed sheath (Fig. 114). Two of the bristles represent the mandibles, and two the maxillæ. The sheath is supposed to consist of the labium and the grown-together labial palpi. This sheath is usually four-jointed, and is never composed of more than that number of segments. The maxillary palpi are wanting.

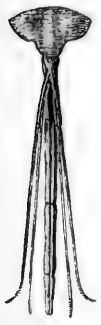

FIG. 114.—Mouth-parts of Bug. (After Muhr.)

Most of the Heteroptera protect themselves by the emission of a disagreeable odor. This is caused by a fluid which is excreted through two openings, one on each side of the ventral aspect of the thorax, behind or near the middle coxa. These openings are termed the *ŏstcoles*. Each of these is usually in some kind of an open channel styled the *ostcolar canal*, and this is surrounded by a more or less rugged and granulated space, the evaporating surface. The legs of the Hemiptera vary greatly in form, but the tarsi are never more than three-jointed.

The lateral margin of the abdominal segments is much developed in several families, and forms a flat, reflexed or vertical border to the abdomen, which is called the *connexīvum*.

In their transformations the Hemiptera pass through an incomplete metamorphosis. The rudimentary wings of the nymphs lie in the normal position, with the lower side of the wing next to the body, and not inverted as with the Jumping Orthoptera. The

males of the Coccidæ present a remarkable exception in the nature of their transformations, the metamorphosis being a complete one.

This order includes three well-marked groups; these are ranked as sub-orders, and are distinguished as follows:

TABLE OF SUB-ORDERS OF HEMIPTERA.

A. Wingless Hemiptera, parasitic upon Man and other Mammals, with a fleshy unjointed rostrum.* I. PARASITA.

AA. Hemiptera with or without wings, but with a jointed rostrum.

B. Wings of the same thickness throughout, and usually sloping at the sides of the body; rostrum arising from the hinder part of the lower side of the head; head without neck, and so closely applied to the prothorax that the first pair of coxæ articulate with the cheeks. II. HOMOPTERA.

BB. First pair of wings thickened at the base, and with thinner extremities, which overlap on the back; rostrum arising from the front part of the head; head (except in *Corisidæ* and *Notonectidæ*) with a more or less distinct neck, so that the cheeks and the first pair of coxæ do not touch each other. III. HETEROPTERA.

Sub-Order I.—PARASITICA.

The *Parasitica* includes certain parasites of Man and other Mammals, commonly known as lice. All the species which have been found in the United States belong to a single family, the *Pediculidæ*. We will not, therefore, enter into a discussion of the characters of the sub-order, but pass directly to a study of this family.

Family I.—PEDICULIDÆ.†

(*Lice.*)

The lice are very small, wingless insects, which live on the skin of Mammalia, and suck their blood. The mouth is furnished with a fleshy, unjointed proboscis, which can be withdrawn into the head, or extended to a considerable length. Within this proboscis are two protrusible knife-like stylets; and at its base, when extended, there is a wreath of re-curved hooks. These hooks serve to anchor firmly the proboscis when inserted in the skin of the infested animal. The eyes are two in number, small and simple. The antennæ have five segments. The legs are joined to the outer margin of the

* This is true of all forms that have been found in the United States. But in the genus *Polyctenus* the rostrum is three-jointed. Two species of this genus are known: these infest bats; one in the West Indies, the other in China.

† *Pediculus*, a louse.

thorax. They are fitted for climbing, being furnished with a powerful curved claw at the tip of the tarsus, which is opposed by a toothed projection of the tibia. This arrangement is admirably adapted for clinging to hairs. The young do not undergo a metamorphosis. Only a few species pertaining to this family are known. The bird-lice, which differ from the true lice in having biting mouth-parts, constitute the family *Mallophagidæ*, of the order Pseudoneuroptera, and should not be confounded with the insects we are now describing.

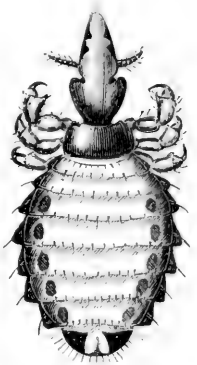

FIG. 115.—*Hæmatopinus asini.* (From Law.)

Three species of lice infest man; these are as follows:

The head-louse, *Pedĭculus căpitis.*—This is the most common species infesting man. It lives in the hair of the head, and is found upon all races of men. It is most common upon the heads of neglected children. Its general color is pale yellowish, with the outer edges of the thorax and abdomen dark brown or gray, and the tarsal claws pale brown. The eggs are oval, and are usually glued by the pointed end to the hair of the host. These "nits" are said to hatch under favorable conditions in about a week from the time they are laid. Under ordinary circumstances, cleanliness and the use of a fine-toothed comb are all that is necessary to insure freedom from this disgusting pest.

The Body-louse, *Pedĭculus vestimĕnti.*—This is somewhat larger than the preceding species. Like the head-louse, it infests all races of men. It is an interesting fact, however, that peculiar varieties have been developed upon the different races. The variety which infests the Whites in this country is yellowish, tinged with gray; "that of the West African and Australian is nearly black; of the Hindoo, dark and smoky; of the Africander and Hottentot, orange; that of the Chinese and Japanese, yellowish brown; of the Indians of the Andes, dark brown; of the Digger Indians of California, dusky olive; and that of the more North American Indians, near the Esquimaux, paler, approaching to the light color of the parasites of the European." * This insect lives upon the skin of most parts of the body; but especially selects the chest and back. It is often trouble-

* Andrew Murray, Economic Entomology, p. 392.

some on ships, in military camps, in prisons, and in the apartments of uncleanly people who neglect to change their clothes. The female attaches her eggs to fibres in the seams of undergarments, from which the larvæ hatch in about a week. This species is exceedingly prolific. The method of destroying these vermin commonly employed in hospitals and poorhouses is to rub mercurial ointment in the seams of undergarments.

The Crab-louse, *Phthĭrius pūbis*.—The common name of this species is suggested by the form of the body, which is nearly as broad as long. When highly magnified, the resemblance of this insect to a crab is quite striking; but to the unaided eye it appears more like a large scale of dandruff. These offensive vermin affect the pubic region and armpits of man, stretching themselves out flat, holding tight to the cuticle, and inflicting most irritating punctures. They can be destroyed by mercurial ointment.

The true lice of cattle, of the horse, ass, swine, squirrel, etc., are very closely allied to the head-louse and body-louse of man. They have been placed, however, by systematists in a distinct genus, *Hæmatopīnus*. The names of the more important species are as fol-

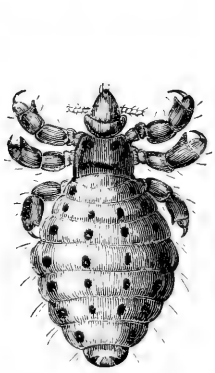

FIG. 116.—*H. eurysternus*. (From Law.)

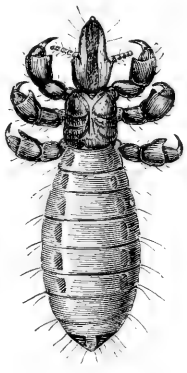

FIG. 117.—*H. vituli*. (From Law.)

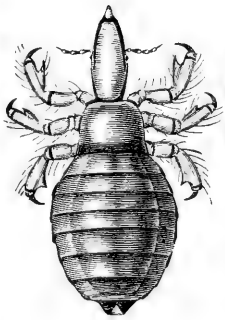

FIG. 118.—*H. suis*. (From Law.)

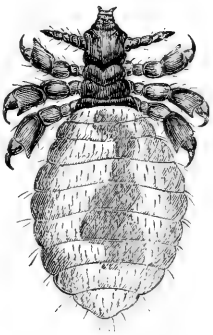

FIG. 119.—*H. piliferus*. (From Law.)

lows: louse of cow, *H. eurystĕrnus* (Fig. 116); a second species found on cattle, especially calves, is *H. vĭtuli* (Fig. 117); louse of horse and ass, *H. ăsini* (Fig. 115); louse of swine, *H. sūis* (Fig 118); louse of the dog, *H. pilĭferus* (Fig. 119); louse of rabbit, *H. ventricōsus*; louse of monkeys, *H. quadrūmanus*.

The reader should bear in mind that certain of the bird-lice, *Mallophagidæ*, infest cattle, the horse, ass, sheep, dog, and cat. These pests have been discussed in an earlier chapter. The true lice of the genus *Hæmatopinus* can be recognized by the figures on the two preceding pages.

For the destruction of these pests upon cattle, poisonous substances must not be used, as injury would result from the animals' licking themselves. They may be safely treated by washing with a strong infusion of tobacco leaves, or by rubbing with an ointment made of one part sulphur and four parts lard, or by sprinkling with Scotch snuff or powdered wood-ashes. The insecticide should be applied thoroughly, leaving no spots untouched where the lice can gather and remain, and from which they can spread over the body again. The application should be repeated several times at intervals of three or four days, in order to destroy the young which may hatch after the first application. It is also necessary, in order to make sure of eradicating the pests, to dress with similar agents, or with strong lye, or kerosene, all places where the cattle have been in the habit of rubbing, and the cracks in the stables where they have stood; or to whitewash the stables and rubbing-places.

Sub-Order II.—HOMOPTERA.*

The Homoptera is that division of the Hemiptera in which the wings are of the same thickness throughout, and, when at rest, usually slope roof-like at the sides of the body. This sub-order is also characterized by the absence of a neck, and the position of the mouth-parts at the hinder part of the lower side of the head. So closely is the head applied to the thorax that usually the front coxæ articulate with the cheeks, and in many forms the mouth-parts appear to arise from between the front legs.

Although the Homoptera is a well-marked group, so well defined that by some it is considered a distinct order, the families of which it is composed show great variations in structure, and modes of development of the species. Some of the most interesting biological problems presented by Entomology have arisen in the study of this sub-order.

TABLE OF FAMILIES OF HOMOPTERA.

A. Beak apparently arising from the sternum, or absent; tarsi one- or two-jointed: antennæ usually prominent and filiform, sometimes wanting.

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* Homŏptera: *homos* (ὁμός), same; *pteron* (πτερόν), a wing.

B. Tarsi one-jointed; adult male without any beak and with only two wings: female wingless, with body either scale-like or gall-like in form, or grub-like, and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer, or of a thin scale beneath which the insect lives. 2. COCCIDÆ.

BB. Tarsi usually two-jointed; wings, when present, four in number.

C. Wings opaque, whitish; wings and body covered with a whitish powder. 3. ALEYRODIDÆ.

CC. Wings transparent.

D. Legs long and slender, not fitted for leaping; antennæ three- to seven-jointed. 4. APHIDIDÆ.

DD. Hind legs fitted for leaping; antennæ nine- or ten-jointed. 5. PSYLLIDÆ.

AA. Beak evidently arising from the mentum; tarsi three-jointed; antennæ minute, setiform.

B. With three ocelli, and the males with musical organs. Usually large insects, with all the wings entirely membranous. 7. CICADIDÆ.

BB. Ocelli only two in number, or wanting; males without musical organs.

C. Antennæ inserted on the side of the cheeks beneath the eyes. 8. FULGORIDÆ.

CC. Antennæ inserted in front of and between the eyes.

D. Prothorax prolonged into a horn or point above the abdomen. 6. MEMBRACIDÆ.

DD. Prothorax not prolonged above the abdomen.

E. Hind tibiæ armed with one or two stout teeth, and the tip crowned with short, stout spines. 9. CERCOPIDÆ.

EE. Hind tibiæ having a double row of spines below. 10. JASSIDÆ.

Family II.—COCCIDÆ.*

(*Scale-insects or Bark-lice, Mealy-bugs, et al.*)

The family *Cŏccidæ* includes the Scale-insects or Bark-lice, Mealy-bugs, and certain other insects for which there are no popular names. In many respects this is a very anomalous group, the species differing greatly in appearance, habits, and metamorphoses from those of the most closely allied families. Not only do the members of this family appear very unlike other insects, but there is a wonderful variety of forms within the family; and even the two sexes of the same species differ as much in the adult state as members of distinct orders.

The males of Coccidæ, unlike all other Hemiptera, undergo a complete metamorphosis. The adult males have only a single pair

* Cŏccidæ, Cŏccus: *coccum*, "the berry that grows upon the scarlet oak." This supposed berry was a bark-louse.

of wings, the hind wings being represented by a pair of club-like halteres. Each of these is furnished with a bristle, which in all of the species I have studied is hooked, and fits in a pocket on the wing of the same side (Fig. 120, 1*a*). The male in the adult state has no organs for procuring food, as the mouth-parts disappear

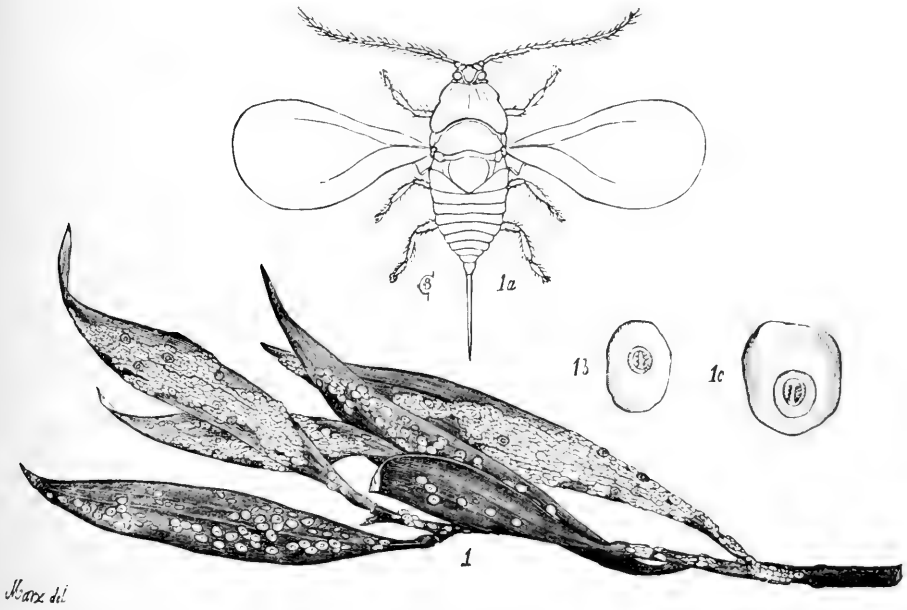


FIG. 120.—*Aspidiotus nerii*. 1, scales on leaves of acacia, natural size; 1*a*, adult male, enlarged; 1*b*, scale of male, enlarged; 1*c*, scale of female, enlarged. (From the Author's Report for 1880.)

during the metamorphosis of the insect, and a second pair of eyes appear in their place. The adult female is always wingless; and the body is either scale-like or gall-like in form, or grub-like and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer, or of a thin scale, beneath which the insect lives.

Among the Coccidæ are found many of the most serious pests of horticulturists. Scarcely any kind of fruit is free from their attacks; and certain species of scale-insects and mealy-bugs are constant pests in conservatories. The ease with which these insects or their eggs can be transported long distances while yet alive, on fruit or living plants, has caused many species that infest cultivated plants to become world-wide in distribution.

During recent years, much attention has been paid to devising methods of destroying these pests. The insecticides which are now most widely used are alkaline washes and kerosene emulsion. (See Chapter XIV.)

A number of useful insects belong to this family. Several species furnish dye-stuffs. The best known of these is *Cŏccus căcti*, the dried bodies of which are known as Cochineal. The stick lac of commerce, from which shell-lac or shellac is prepared, is a resinous substance excreted by one of the Coccinæ, *Cartēria lăcca*, which lives on the young branches of several tropical trees. And the bodies of this insect, which are obtained from the stick lac, furnish the coloring agent known as lac dye. China wax is another substance for which we are indebted to this family. It is the excretion of an insect known as Pe-la, *Ericerus pe-la*. In fact, many species of this family excrete wax in considerable quantities. I have found three species in this country which, if they can be easily cultivated, produce wax in sufficient quantities to be of economic importance.

The family comprises four sub-families. One of these includes species that live in galls, and is confined to Australia. The three sub-families which are represented in our fauna can be separated by the following table: *

A. Body either naked or clothed with a secretion; the clothing, however, not in the form of a scale composed in part of moulted skins.

B. Body of female usually remaining distinctly segmented, and retaining the power of motion till maturity; sometimes, however, it becomes more or less globular and fixed, but in all cases the labium is composed of several segments, and there are no anal plates. (Fig. 121, *ap.*) The abdomen usually ends in a pair of lobes, each furnished with one or more bristles (Plate IV. Fig. 1*e*).

1. COCCINÆ.

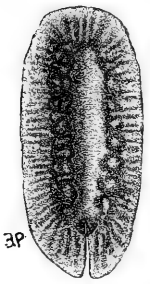
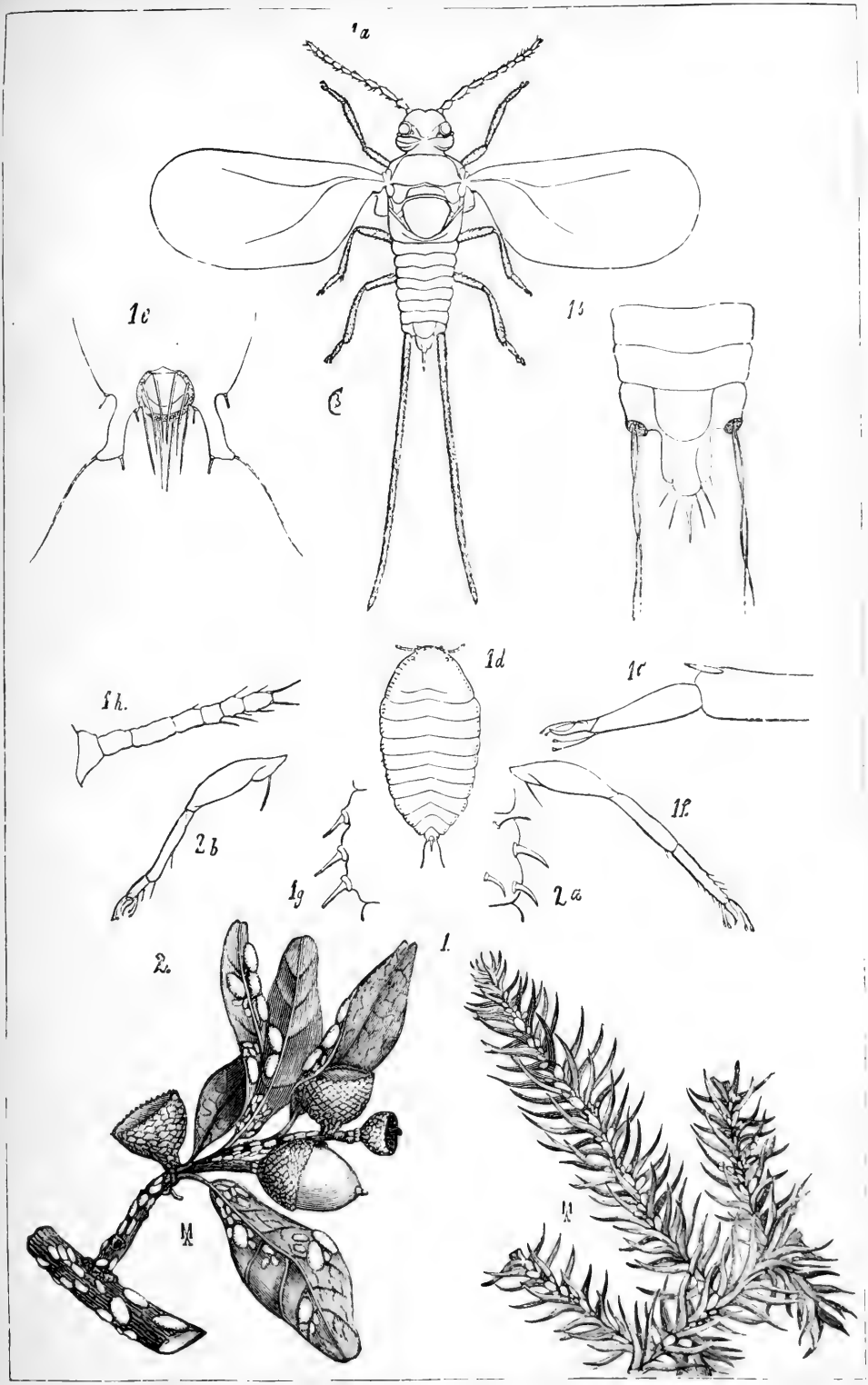


FIG. 121.—*Lecanium*, enlarged, *ap*, anal plates.

BB. Body of female changing much in form during development, becoming scale-like or more or less globular, with the segmentation absent or indistinctly indicated. The individuals usually become fixed to the plant upon which they live; sometimes they are enclosed in a covering of wax. In all cases the labium is composed of a single segment; the caudal opening of the alimentary canal in the adult female is covered by a pair of subtriangular plates (Fig. 121, *ap*). 2 LECANINÆ.

* The characters given here for distinguishing the Lecaninæ and Coccinæ are merely provisional, as these groups are not yet well known.


1a
1c
1b
♀
1h.
1d
1e
2b
1f.
1g
2a
1.
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M

AA. Body of insect covered by a scale composed in part of moulted skins and partly of a secretion of the insect. 3. DIASPINÆ.

Sub-Family I.—COCCINÆ.

The sub-family *Coccīnæ* includes those Coccids of which the females undergo the least change in form during their development. The majority of them retain a form not much different from that of the young larvæ; but in some genera the body becomes a globular mass, with little or no indication of segmentation. The most important characters, as the family is now understood, are the multiarticulate labium, and the absence of anal plates. Plate IV. 1*d* represents the typical form of the female adult in this sub-family; 1*e* represents the caudal end of the body of the same. The most common exception to this form is that of the genus *Kermes* described below. In most genera of this sub-family the body of the female becomes enclosed in a cottony or felt-like sac. In some, as the mealy-bugs, this takes place just before they begin to oviposit; while in other genera the greater part of the life of the insect is passed within the sac. In this and the next sub-family the caudal style of the male is short; and the last abdominal segment bears a pair of long waxy filaments. Each filament is supported by one or more hairs, at the base of which are the spinnerets from which the wax is excreted (Plate IV. 1*a* and 1*b*).

Mealy-bugs, *Dactylōpius*.—The mealy-bugs are the best known members of this sub-family, as they are the most common and most noxious of green-house pests. Fig. 122 represents *D. longifilis*, a common species in green-houses. *D. destrŭctor* (Fig. 123) is another common species, which differs in lacking the long filaments

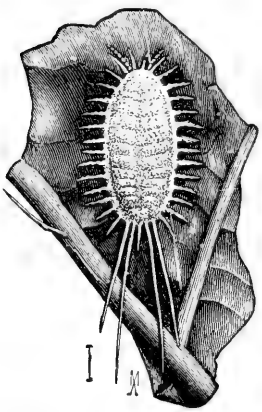


FIG. 122.—*Dactylopius longifilis*, female, enlarged. (From the Author's Report for 1880.)

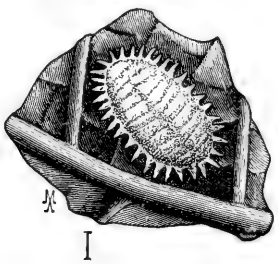


FIG. 123.—*Dactylopius destructor*, female, enlarged. (From the Author's Report for 1880.)

of the preceding species. This occurs in green-houses in the North, and is also very destructive to orange-trees in Florida.

Cochineal, *Cŏccus căcti.*—This is a native of Mexico, but is now cultivated in India, Spain, and other countries. It feeds upon various species of the Cactaceæ, more especially *Opuntia coccinilifera.* I have received living specimens which were collected upon a wild cactus in Florida. The dye-stuff consists of the female insects, which, when mature, are brushed off the plants, killed, and dried. The entire insect is used. From cochineal, lake and carmine are also prepared. Cochineal is now being superseded by aniline dyes, which are made from coal-tar.

Orthēzia.—The members of this genus occur not uncommonly on various weeds. They are remarkable for the calcareous secretion with which the body is clothed. This is in the form of long plates. Fig. 124 represents a nymph; in the adult female, the excretion becomes more elongated posteriorly, and forms a sac containing the eggs mixed with a fine down. Later, when the young are born, they remain in the sac till they have themselves secreted a sufficient amount of the lamellar matter to cover them.

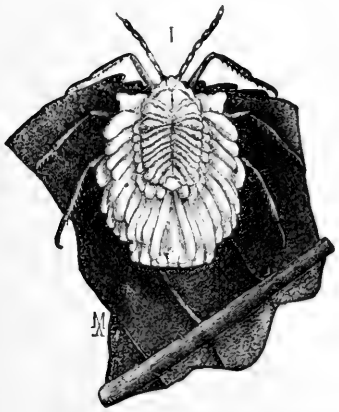


FIG. 124.—*Orthezia*, enlarged. (From the Author's Report for 1880.)

FIG. 125.—*Icerya purchasi.* Females, adult and young, on orange. (From the Author's Report for 1880.)

Icērya purchasi.—This beautiful insect (Fig. 125) is one of the most dangerous pests infesting fruit-trees in California. The body of the adult female is scale-like, dark orange-red, and has the dorsal surface more or less covered with a white or yellowish-white powder. The insect secretes a large egg-sac, which causes it to resemble Pul-

vinaria, of the next sub-family. The egg-sac of Icerya, however, is beautifully ribbed, while that of Pulvinaria is not of very definite form. Icerya is an introduced insect from Australia.

Rhizocŏccus.—Two species of *Rhizococcus* are figured on Plate IV. Fig. 1 represents *R. araucāriæ*, a species infesting Norfolk Island pine (*Araucaria excĕlsior*) in southern California; and Fig. 2 is of *R. quĕrcus* upon oak from Florida. This genus is a good illustration

FIG. 126.—*Kermes* sp., on *Quercus agrifolia*. Adult females on stem; immature males on leaves. (From the Author's Report for 1880.)

of the forms that spend a greater part of their lives within sacs. A more common illustration of this occurs in the genus *Eriocŏccus*, of which we have a species, *E. azāleæ*, common upon azaleas in conservatories.

Kĕrmes.—The most abnormal members of this sub-family constitute the genus *Kermes*. Species of this genus are common upon

oaks wherever they grow. These insects are remarkable for the wonderful gall-like form of the adult females. So striking is this resemblance, that they have been mistaken for galls by many entomologists. Fig. 126 represents a species of this genus upon *Quercus agrifolia*. The gall-like swellings on the stem are the adult females; the smaller scales on the leaves are the immature males.

Sub-Family II.—Lecaninæ.*

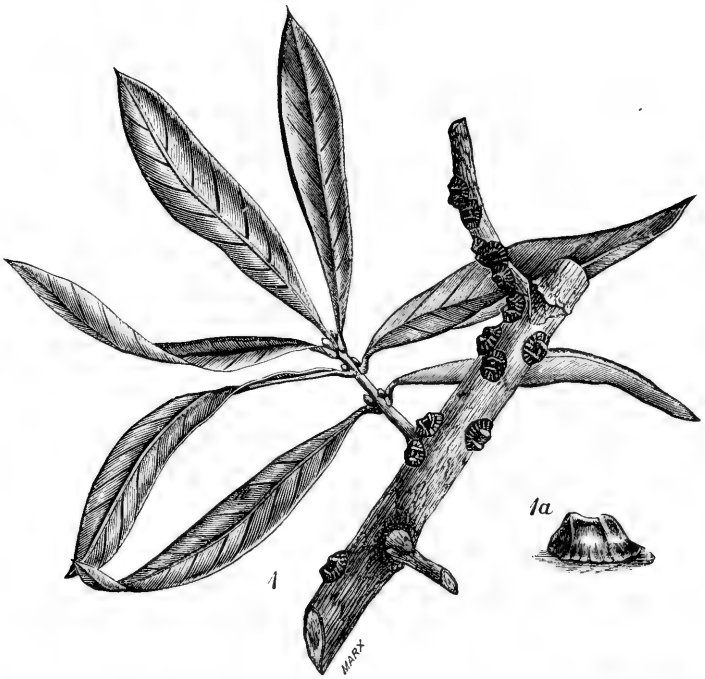
In the present state of our knowledge of this sub-family there is nothing to add to the characterization of it given in the table on page 136. The most available character for recognizing these insects is the presence of the subtriangular anal plates (Fig. 121). Usually, the body is elliptical or circular in outline, with a deep incision at the caudal end, leading to the anal opening (Fig. 121). Although as a rule these insects remain fixed to one spot after the wandering larval stage, I have seen the adults of certain species move from one place to another. It is a curious fact that in certain species, among them the most common ones, as *L. hesperidum*, the males are unknown. It seems probable that they rarely, if ever, occur. Only three genera have been found in the United States. These are distinguished as follows:

A. Body naked or nearly so.
  B. Female secreting a mass of cottony material in which the eggs are laid. Fig. 127. 2. Pulvinaria.
  B. Female laying her eggs beneath her body, not excreting a mass of cottony material. 1. Lecanium.
AA. Body covered with a layer of wax. 3. Ceroplastes.

Lecānium.—The species of the genus *Lecanium* abound everywhere; they occur on all kinds of plants both in conservatories and in the open air. Some of them are known to gardeners as "Soft-scales." The genus is one that is easily recognized, but no one has yet found satisfactory characters for separating the closely allied species. I have figured three of the more common forms. Plate V. 2 is of *Lecānium hespĕridum*. This is a representative of a group that includes our most common species. They are an elongated oval in outline, nearly flat, and smooth and shining.

Lecānium hemisphærĭcum (Plate V. 3) is a much more convex species, as its name indicates. It is common in conservatories.

* Lecanīnæ, Lecānium: *lecane* (λεκάνη), a dish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MARX


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3
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2

Lecānium ōleæ also occurs in conservatories, but it is very common in the open air in California. Here it is a serious pest of the orange,

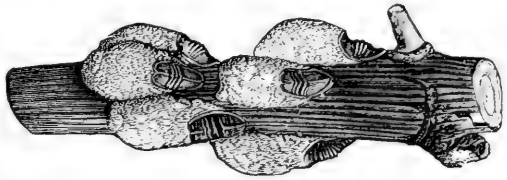


FIG. 127.—*Pulvinaria innumerabilis.* Female on grape, natural size. (From the Author's Report for 1880.)

olive, and other trees. It is very convex and marked with prominent ridges (Plate V. 1). Especially prominent are two transverse ridges and a longitudinal one which frequently form a raised surface of the form of a capital H.

FIG. 128.—*Ceroplastes floridensis*, adult and young females on Ilex, natural size; *a*, young female, enlarged; *b*, adult female, enlarged. (From the Author's Report for 1880.)

FIG. 129.—*Ceroplastes cirripediformis.* Adult females, natural size; *a*, female enlarged. (From the Author's Report for 1880.)

Pulvināria.—This genus is distinguished from Lecanium only by

the fact that the adult female excretes a large cottony mass in which the eggs are laid. Fig. 127 represents *Pulvināria innumerābilis*, which is common on grape, maple, osage orange, and other plants.

Ceroplāstes.—The species belonging to this genus are furnished with a thick covering of waxy material, which does not, however, adhere closely to the insect. Only two species have been found in the United States. Both of these are Florida insects, and in each the waxy covering is dirty-white in color. The most common species, *C. Floridĕnsis* (Fig. 128), infests a great variety of plants both wild and cultivated. *C. cirripediformis* (Fig. 129) is not very common; it infests orange and quince. It is a beautiful species, as the waxy excretion is in the form of regular-shaped plates.

Sub-Family III.—Diaspinæ.*

The *Diaspīnæ* includes those species of scale-insects that form a scale composed in part of moulted skins, and partly of an excretion of the insect. This apparently trivial character is correllated with important structural characters, which mark a well-defined group. The

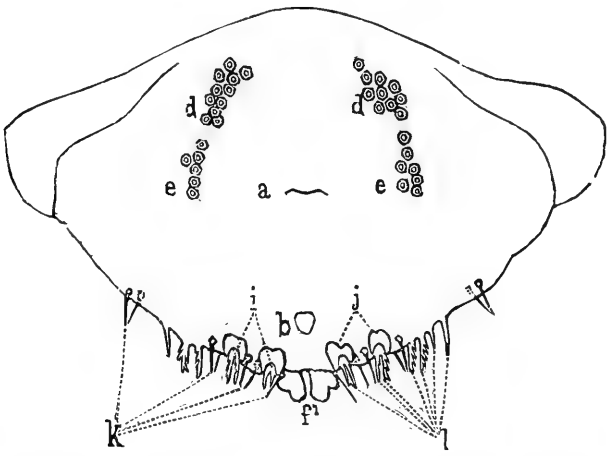
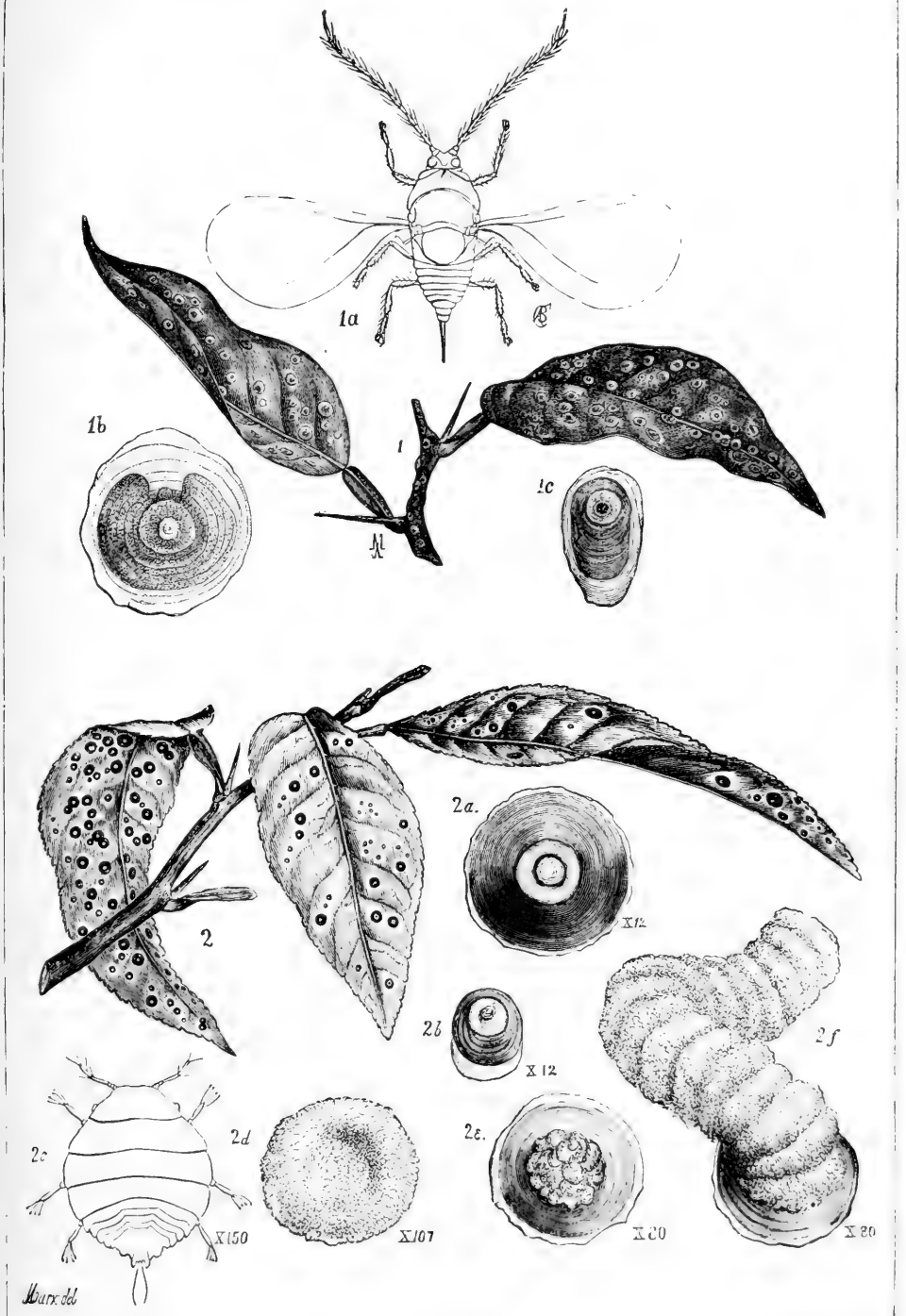


Fig. 130.—Organs of the last segment of adult females of the *Diaspinæ*. *a*, opening of oviduct; *b*, anus; *d*, *d*, cephalo-lateral groups of spinnerets; *e*, *e*, caudo-lateral groups of spinnerets; *f'*, lobes; *k*, spines; *l*, plates (these are frequently described by authors as spines). (From a Report by the Author, 1881.)

most important of the structural characters is the peculiar form of the last segment of the body. This segment is highly specialized for the excretion and manipulation of wax. It is furnished with many openings and appendages. These vary greatly in number and form, and afford good characters for distinguishing closely allied

* Diaspīnæ, Diăspis: *dia* (δια΄,) through; *aspis* (α᾽σπίς), a shield.


1a
1b
1
1c
2
2a.
X12
2b
X 12
2c
X150
2d
X107
2e.
X 20
2f
X 80

species. Figure 130 represents a common form of this segment. But these special characters of this segment are not presented by the larvæ till after the first moult, nor by the male after the change to pupa.

The following account of the metamorphoses of the Diaspinæ is quoted from my report on Scale-Insects in the Annual Report of the U. S. Department of Agriculture for 1880.

The newly-hatched scale-insect is oval in outline, much flattened, furnished with six legs, a pair of antennæ, and an apparatus for sucking the juices from plants. (See Plate VI. Fig. 2*c*, young of *Aspidiotus ficus*.) At this stage of its existence it is very small, a mere speck, which the untrained eye could only with difficulty detect. By means of a lens, however, these minute creatures can be seen crawling in all directions over the leaves or bark of an infested tree. After wandering for a time, usually but a few hours or even less, the young scale-insect settles on some part of the plant, inserts its beak, and drawing its nourishment from the plant, begins its growth at the expense of its host. In a short time there begins to exude from the body of the larva fine threads of wax, which are cottony in appearance. The excretion of this wax continues until the insect is completely covered by it. The rate at which this excretion is produced varies greatly. Thus larvæ of the red scale of Florida (*Aspidiotus ficus*), which were only one day old, were found to be completely covered by the cottony mass which they had excreted; while the larvæ of Glover's scale (*Mytilaspis Gloverii*) did not become entirely covered until they were six days old. Sooner or later the larva begins to excrete a pellicle, which, although very thin, is dense and firm in texture. The mass of cottony fibres either melts or is blown away, or, as in certain species of Aspidiotus, a portion remains as a white dot or ring on the centre of the scale. After a period, which, in several species that we have studied, is about one-half of the time from the hatching of the larva to the emerging of the male, or one-third of the time from the birth of the female to the date at which she begins ovipositing, the larva sheds its skin. In some species this does not take place until after the beginning of the formation of the permanent scale, and in such cases the moulted skin adheres to the inner surface of the scale; and cannot be seen while it is in its normal position on the plant. This is true of many species belonging to the genus Aspidiotus (*A. ficus*, *A. citri*, *A. perniciosus*, and others). In these species the position of the exuviæ is indicated by a nipple-like prominence, often marked by a white ring or dot, which is the remains of the cottony mass first excreted. In other species the moult takes place before the beginning of the excretion of the permanent scale. In these, the larval skin is plainly visible either upon the surface of the scale, as in certain species of Aspidiotus (*A. nerii*, Fig. 120), and in Diaspis (Plate VIII. Fig. 1*a*, 2*a*), or at one extremity, as in Mytilaspis (Plate X. Fig. 1*a*). Sometimes, however, the larval skin is covered by a delicate transparent layer, which, I think, is the melted or compacted remains of the cottony mass excreted by the young larva (Plate X. Fig. 2*a*).

The change which the larva undergoes at this moult is a very remarkable one, appearing to be a retrogression, instead of an advancement to a more

highly organized form, as is the rule in the development of animals. With the skin are shed the legs and antennæ.* The young scale-insect thus becomes a degraded grub-like creature, with no organs of locomotion. The mouth-parts remain, however, in a highly developed state and are well fitted to perform their functions. This apparatus is not the least remarkable thing in the structure of these insects. It is terminated by a thread-like organ, which is frequently much longer than the body of the insect, and is composed of four delicate hair-like bristles. By means of this organ the insect is firmly attached to the plant, and draws its nourishment therefrom. From this stage the development of the sexes differs.

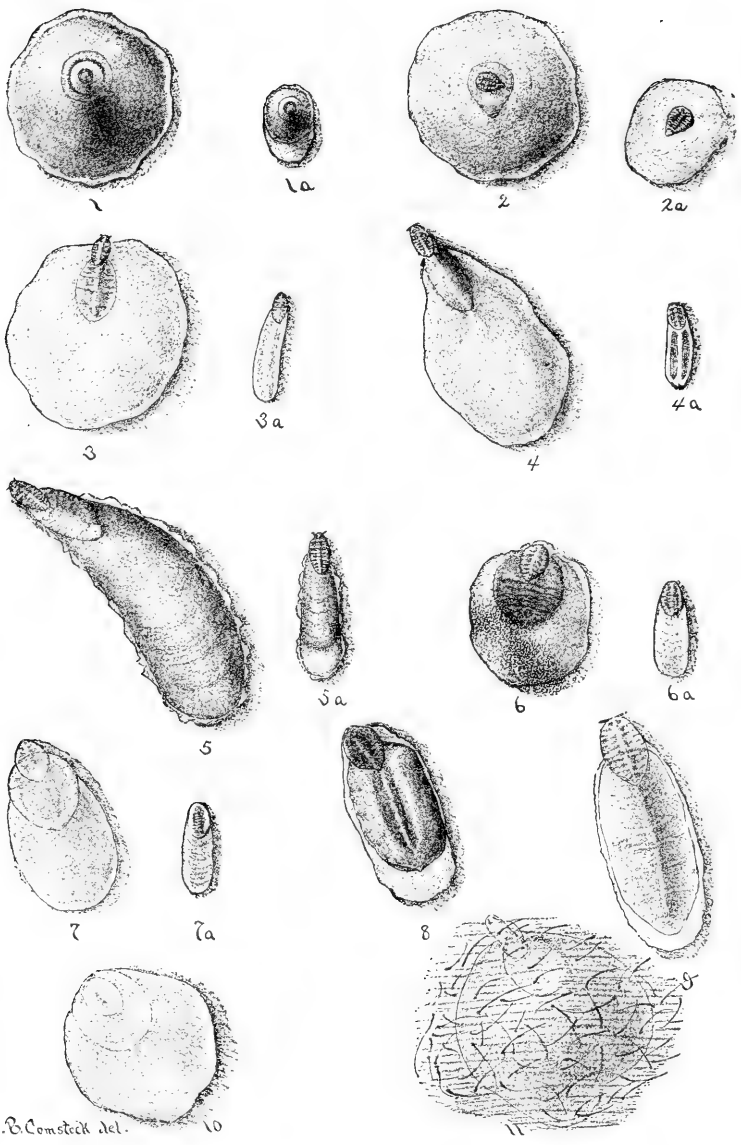
The second and last moult of the female takes place, in those species which we have studied most carefully, when she is about twice as old as when the first moult occurred. The change in appearance at this moult presents nothing remarkable. The second cast skin is joined to the first, and with it forms a part of the scale which covers the body of the insect. Sometimes, as in the genus Uhleria (Plate VII. Fig. 9), this moulted skin is very large and constitutes the greater part of the scale; but more commonly the exuviæ form but a small proportion of the scale, the greater part of it being excreted subsequently to the second moult. Soon after the second moult of the females takes place the adult males emerge, and doubtless the impregnation of the females occurs at once. After this, the body of the female increases in size, becoming distended with eggs. The oviposition takes place gradually, and, in those species that we have studied, begins when the female is about three times as old as when the first moult occurred. The eggs are deposited beneath the scale, the body of the female gradually shrinking and thus making room for them. (See Plate X. Figs. 1*b* and 2*c*.) Some species, however, are viviparous.

The male scale-insect during the early part of its larval life is indistinguishable from the female. The first moult occurs at the same time and is accompanied by a similar change, the male larva, like the female, losing its legs and antennæ. The second moult is also synchronous with the second moult of the female; but here the similarity in form between the two sexes ceases. Even before this moult takes place there may be observed the formation of rudimentary limbs beneath the transparent memberless skin of the larva; and after this skin is shed, the male, now in the pupa state, differs remarkably from the female. The male pupa has long antennæ, and its legs and wings, although in a rudimentary state, are very large. The duration of the pupa state in those species which we have bred, in short, lasting but a few days; and then, after a third casting of the skin, the adult male appears.

The outline figures on Plates IV., VI., and IX. represent the insect in this stage. The anterior wings, though very delicate, are large, and enable the male to fly readily. The posterior wings are represented only by a pair of halteres. These insects resemble in this respect the flies, gnats, and other insects belonging to the order Diptera, or two-winged insects. The posterior end of the body is furnished with a style, which is sometimes nearly as long as the remainder of the body, and is the external organ of reproduction. As our figures represent only a dorsal view, the most remarkable character of the

* Rudiments of antennæ are sometimes retained, as in certain species of *Mytilaspis*.

PLATE VII.



Scales of the *Diaspinæ*, from camera-lucida drawings. 1, *Aspidiotus ficus*, female; 1*a*, male of same; 2, *Aspidiotus nerii*, female; 2*a*, male of same; 3, *Diaspis rosæ*, female; 3*a*, male of same; 4, *Chionaspis furfurus*, female; 4*a*, male of same; 5, *Mytilaspis pomorum*, female; 5*a*, male of same; 6, *Parlatoria pergandii*, female; 6*a*, male of same; 7, *Parlatoria proteus*, female; 7*a*, male of same; 8, *Parlatoria zizyphi*, female; 9, *Uhleria camelliæ;* 10, *Aspidiotus? parlatoroides*, female; 11, *Chionaspis? biclavis.*

adult—the supplementary eyes which takes the place of the mouth-parts—is not shown.

The genera of the Diaspinæ are characterized chiefly by the form of the scales, and the position of the moulted skins or exuviæ upon them. In the use of these characters it is necessary to distinguish the sex of the individual by which a given scale was made. This can be done as follows: In the scale of the fully developed female there are two moulted skins, while in that of the male there is but one. Our genera can be separated by the following table:*

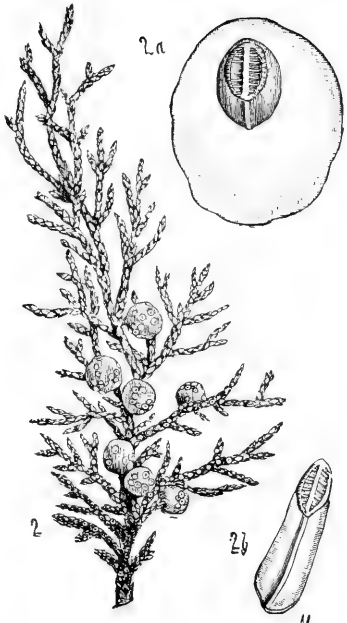
A. Scale of female circular with the exuviæ either central or more or less nearly marginal.
  B. Scale of male but little elongated, with the exuviæ more or less central; scale usually resembling that of the female in color and texture (Plate VII. Fig. 1*a* and 2*a*). ASPIDIOTUS.
  BB. Scale of male elongated, with the exuviæ at one extremity.
    C. Scale of male, white and carinated (Plate VII. Fig. 3*a*). DIASPIS.
    CC. Scale of male, not white and with no central carina (Plate VII. Fig. 6*a*). PARLATORIA.
AA. Scale of female elongated, with the exuviæ at one extremity.
    D. Exuviæ small.
      E. Scale of male, white and carinated† (Plate VII. Fig. 4*a*); last segment of female with five groups of spinnerets. CHIONASPIS.
      EE. Scale of male white, but not carinated; female with eight groups of spinnerets. POLIASPIS.
      EEE. Scale of male similar in form to that of the female (Plate VII. Fig. 5*a*). MYTILASPIS.
    DD. Exuviæ large.
      F. Two moulted skins visible on the scale of the female (Plate VII. Fig. 7, 8). PARLATORIA.
      FF. Second skin covered by a secretion (Plate I. Fig. 9). UHLERIA.

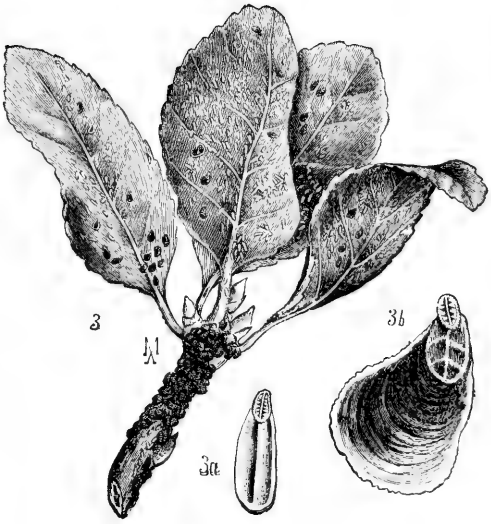
The accompanying illustrations, from my report on scale-insects in the Report of the U. S. Dept. of Agriculture for 1880, will enable the reader to recognize the more important species of this sub-family.

Aspidiōtus.—This is the largest genus of the Diaspinæ; more than twenty species have been observed in the United States. The one which has done the greatest injury to citrus fruits on the Pacific coast is the Red Scale of California, *Aspidiōtus aurăntii* (Plate VI. 1). Closely allied to this is the Red Scale of Florida, *A. fīcus* (Plate VI.

* From the author's Second Report on Scale-Insects; published in the Second Report of the Cornell University Experiment Station. Ithaca, N. Y., 1883.

† In *Chionaspis ortholobis* the scale of the male is not carinated. This species infests willow in California.





Marx del

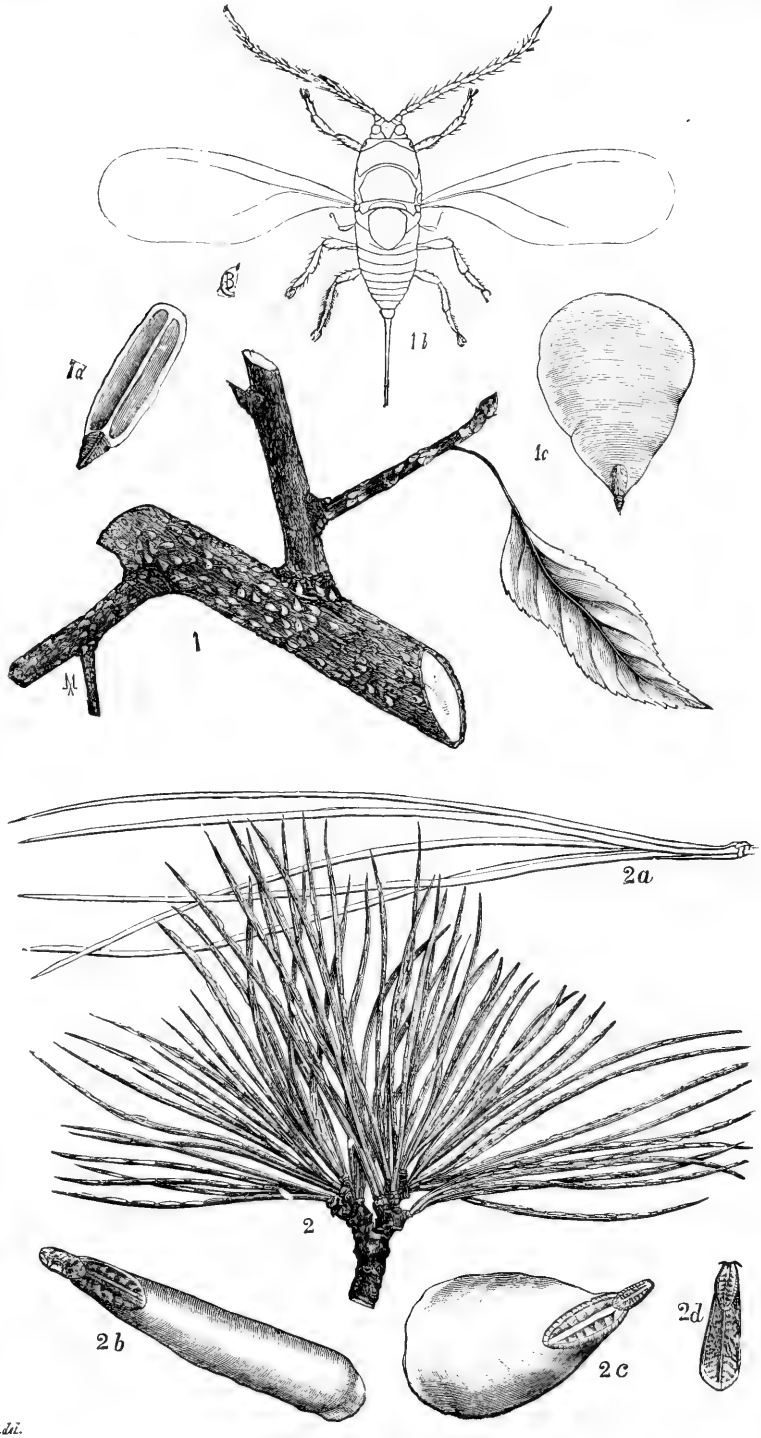
2). This also infests oranges; but its injuries are overshadowed in Florida by those of other scale-insects; *A. nĕrii* (Fig. 120) is the common white scale, which occurs on a great variety of plants. It is an imported insect; but I have collected it throughout our country from the Great Lakes to the Gulf of Mexico, and from the Atlantic to the Pacific; in the colder parts of the United States it is, next to the mealy-bugs and Lecanium, the most common Coccid on house-plants. In northern California, and especially in the Santa Clara Valley, is found *A. perniciōsus;* this is a circular, grayish scale which infests nearly all of the deciduous fruit-trees grown in that State. It is the most destructive of the scale-making Coccids; and before the fruit-growers awoke to the importance of fighting it, it came near destroying the orchards of that section.

Diăspis.—Our commonest representative of this genus is *Diăspis rōsæ* (Plate VIII. 1); this is a snowy-white scale, which occurs abundantly on neglected roses; I have found it also on raspberry, and blackberry bushes. *Diăspis carucli* (Plate VIII. 2) is common in some localities on Juniper and allied plants.

Chionăspis.—The common white scale of pear and apple is *Chionaspis fürfurus* (Plate IX. 1). Another common species which occurs throughout the United States upon the leaves of pine and spruce is *C. pinifōlii* (Plate IX. 2). *C. cuŏnymi* (Plate VIII. 3) infests Euonymus; it is remarkable for having the scale of the female of a dirty blackish-brown color, instead of white, as is the rule in this genus. The common white scale of willow is *C. sălicis.*

Mytilăspis.—To this genus belong some of the best known Coccids. Of those that occur on plants in the open air, only three American species have been recognized. Two of these abound on oranges. One of the orange species, *M. glovĕrii,* (Plate X. 2,) can be easily recognized by the very narrow form of the scale, and the fact that the eggs are laid in two rows beneath the scale (Plate X. Fig. 2, *c*). In the other orange species, *M. citrĭcola,* (Plate X. 1,) the scale of the female is much wider, and the eggs are massed irregularly beneath the scale. The Oyster-shell Bark-louse of the Apple, *M. pomōrum,* is distinguished from M. citricola only by minute characters. The figure just referred to would serve equally well for this species, except that it does not occur on the orange. It is the most common scale of the apple in all parts of the United States in which that tree grows; it infests also a great variety of other plants.

The food-plants of the species figured on Plate VII., and not named above, are as follows: *Parlatōria pergăndii* occurs on Florida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2c
2d

oranges. *Parlatōria prōteus* has been found only on exotic plants in conservatories. *Parlatoria zizyphi* is an exotic species which is often found on imported oranges. *Uhlēria camĕlliæ* is a troublesome pest of the camellia in conservatories. *Aspidiōtus parlatorōīdes* infest the Bay Tree in Florida. And *Chionăspis biclāvis* is a remarkable species, which I found burrowing beneath the epidermal layer of certain exotic plants in the conservatories at Washington.

Family III.—Aleyrodidæ.*

(*Aleyrodes.*)

The insects of the genus *Aleyrōdes* were for a long time classed with the Coccidæ. In their immature state they are scale-like in form (Fig. 131), and often somewhat resemble certain species of Lecanium. But the mature insects differ so much from Coccids that the genus has been separated as a distinct family. They are very small insects; the species with which I am acquainted have an expanse of wings of about three millimeters. Both sexes are winged; and, as with other Hemiptera except the Coccids, there are two pairs of wings. In the adult state, all the species are of nearly the same color; the wings are white, sometimes spotted; the body is usually yellowish, sometimes pinkish, and more or less spotted with black. The most striking character presented by the adults, in addition to the fact that both sexes are winged, and each has two pairs of wings, is the presence of a whitish powder with which the wings and body are covered. It is this character which gives the name to the genus.

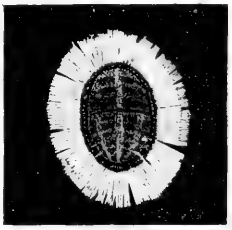
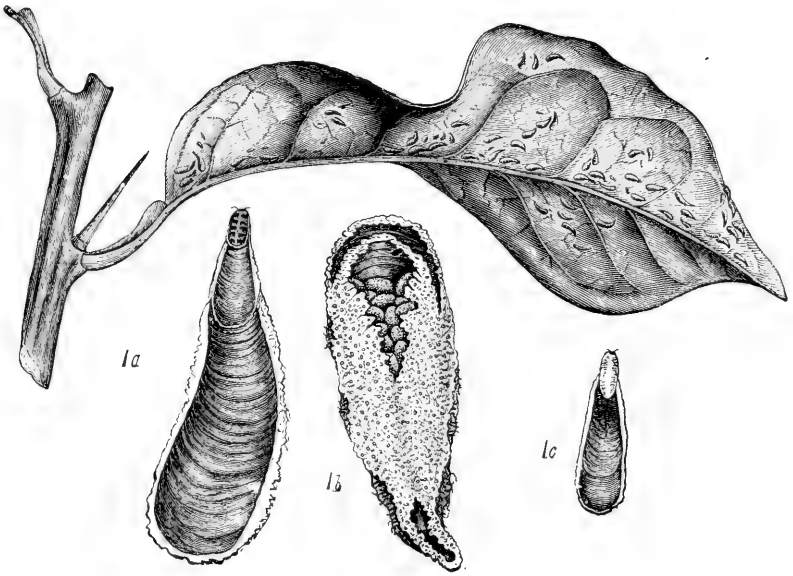


Fig. 131.—*Aleyrodes.*

With the adults the eyes are reniform, and generally divided into two portions, separated by a membrane; in some species they are more or less rounded or triangular. Above each eye there is a minute ocellus. The rostrum is stout, and composed of three segments. The antennæ are seven-jointed. The wings in repose are carried nearly horizontally. The first pair are the larger, and are traversed by two veins; the first vein, which passes through the middle of the wing, is much the larger; the hind wings have only a single vein.

* Aleyrŏdidæ, Aleyrōdes: *aleurōdes* (ἀλευρώδες), like flour.


1a
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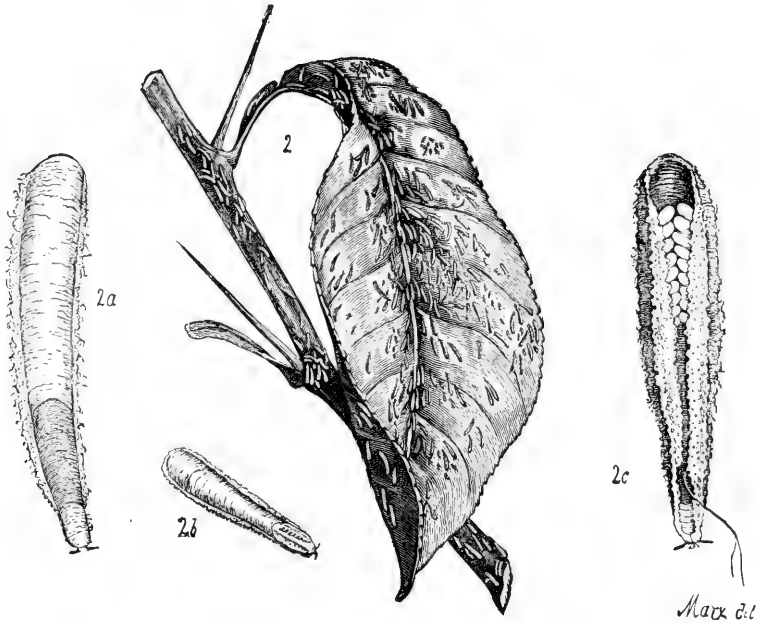
2
2a
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Marx del.

Owing to their small size and similarity in color, it is difficult to distinguish the different species of Aleyrodes in the adult state. But the immature scale-like forms present considerable differences. The most common form that I have met is very flat, nearly circular in outline, and furnished with a beautiful white fringe (Fig. 131); this fringe is composed of parallel fibres, which radiate from the margin of the body; and its white color contrasts strongly with the dark color of the insect. The segmentation of the body is often represented by prominent wrinkles, which give the insect a miniature resemblance to the fossils known to geologists as Trilobites. Sometimes the fringe of excretion is wanting; and in a common species on maple, the excretion from the margin of the body, instead of extending laterally and forming a fringe, is directed towards the leaf upon which the insect rests, and thus the body is lifted away from the leaf, and perched upon an exquisite palisade of white wax (Fig. 132).

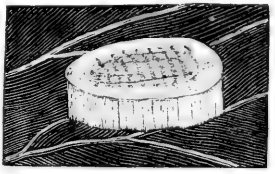

FIG. 132.—*Aleyrodes* on maple.

The American species of this family have not been studied. In case any of them become destructive to vegetation, they can probably be destroyed by strong alkaline solutions, as are Coccids.

Family IV.—APHIDIDÆ.*

(*Plant-lice.*)

The plant-lice are well-known insects; they infest nearly all kinds of vegetation in all parts of the country. Our most common examples are minute, soft-bodied, green insects, with long legs and antennæ, which appear on various plants in the house and in the field. Among our common species are both winged and wingless forms. There are a great number of species, nearly all of which are of small size. The bodies of our largest species measure only 6 or 7 mm. (0.24 or 0.25 inch) in length.

The body is usually more or less pear shaped. The winged forms have two pairs of delicate, transparent wings. These are furnished with a few simple veins; but the venation is more extended

* Aphĭdidæ, Āphis: perhaps from *aphysso* (ἀφύσσω), to drink up liquids.

than in either of the two preceding families. The first pair of wings is larger than the other; and the two wings of each side are usually connected by a compound hooklet. The beak is two-jointed, and varies greatly in length; sometimes it is longer than the body. The compound eyes are prominent; and ocelli are also usually present. The antennæ are from three- to seven-jointed. On the dorsal aspect of the sixth abdominal segment there is, in many species, a pair of tubes, through which a sweet, transparent fluid is excreted. In some genera these organs are merely perforated tubercles; while in still other genera they are wanting.

The fluid which is excreted through the abdominal tubercles is the substance known as honey-dew. It is sometimes produced in such quantities that it forms a glistening coating on the leaves of the branches below the plant-lice, and stone walks beneath shade-trees are often densely spotted with it. This honey-dew is fed upon by bees, wasps, and ants. The bees and wasps take the food where they find it, paying little, if any, attention to its source. But the ants recognize in the plant-lice useful auxiliaries, and often care for them as man cares for his herds. This curious relationship will be more fully discussed under the head of ants.

In addition to honey-dew, many Aphids excrete a white substance. This may be in the form of a powder, scattered over the surface of the body, or it may be in large flocculent or downy masses; every gradation between these forms exists.

The plant-lice are remarkable for their peculiar mode of development. The various species differ greatly in the details of their transformations; but the following generalizations can be made.

At some period eggs are produced by impregnated females. This ordinarily occurs in the autumn; in which case the eggs do not hatch till the following spring. From the fact that these eggs are fertilized, they are frequently referred to as true eggs, in contradistinction to pseudova, described later. These true eggs are also known as *winter eggs*.

From the winter eggs there hatch in the spring a generation of Aphids in which there is no distinction of sex. All are females; and each has the power of reproducing without the intervention of a male. Such reproduction is termed *agămic* * *reproduction*, or reproduction by budding. And this term is also applied to the individu-

* Agămic: *a* (α), without; *gamos* (γάμος), marriage.

als that reproduce in this way. Usually, the agamic generation produced by the winter eggs is wingless. The agamic female which hatches from a winter egg, being the starting point from which arise the generations that intervene between this egg and the production of other true eggs, is termed the *stem-mother*.

The offspring of the stem-mothers are wingless or winged or both, and are agamic. In many cases they are born alive. This can be seen by examining almost any colony of plant-lice during the summer-time. While an agamic mother is unconcernedly feeding or walking about, it may be giving birth to a young louse; the latter can be seen with the unaided eye, but better with a lens, emerging from the caudal end of its mother, tail first, and kicking vigorously, even before its head has been delivered. In other cases, the agamic form produces egg-like bodies, which are termed *pseudōva*, to distinguish them from the fertilized or true eggs. And, in still other cases, they produce living young, which are enveloped in a pellicle, from which they emerge in the course of a few minutes; such an enveloping pellicle with its enclosed young is also termed a pseudovum.

The number of agamic generations that may follow without the intervention of sexual forms varies with different species, and, in some cases at least, varies in the same species, depending upon temperature and other conditions. Thus Kyber, in the early part of this century, succeeded, by keeping the insects in a warm room, in raising a series of agamic generations of two species of Aphids, which extended through four years without the intervention of sexual forms.

As already indicated, the agamic generations are of two forms, wingless and winged. Each of these has a peculiar function in the economy of the species. The wingless generations, which are usually the more numerous, by their great fecundity provide for the enormous and rapid multiplication of individuals, which is so characteristic of these insects. But this great increase of individuals would be disastrous to the species, by the destruction of the infested plants and the consequent starving of the insects, were it not supplemented by other powers. We find, therefore, interspersed among these wingless sedentary generations, generations which are winged and migrating. Thus the spread of the species is provided for.

Generally on the setting in of cold weather, or in some cases on the failure of nourishment, the weather being still warm, there is produced a generation including individuals of both sexes. The

males may be either winged or wingless; but, so far as is known, the females that pair with the males are always wingless. These females, after becoming impregnated, produce the winter eggs; thus is completed the cycle of changes through which the species passes. In many cases, at least, the individuals of the agamic generation that immediately precedes the sexual one produce but few pseudova; from these pseudova the sexual individuals emerge, not as larvæ, but as fully developed individuals, ready to pair and reproduce; in fact, in the cases referred to, the sexual individuals have the mouth-parts in a rudimentary state, and take no nourishment. In many species, the impregnated female produces a single egg, which is nearly as large as the insect herself; frequently this egg is not laid, but remains throughout the winter in the dry skin of the dead parent.

Agamic Aphides may hibernate, and may coexist with the sexual generation of the same species.

From the above generalizations it will be seen that a single species of plant-louse may present three distinct forms: first, a sedentary, agamic, wingless form, furnished with mouth-parts; second, a migrating, agamic form, which is winged and furnished with mouth-parts; third, a sexual form, of which the females are wingless, while the males may be either winged or wingless; in certain cases, at least, the sexual forms are mouthless.

There is unfortunately a generalization in most of the text-books on entomology that is incorrect. It is that the winged generation is produced only on the approach of cold weather, and that this generation is the sexual one.

Plant-lice are often very destructive to vegetation; they appear, however, to be more liable to attack unhealthy plants than those that are in good condition. The best method of destroying these pests is by spraying with a strong solution of soap, or with kerosene emulsion. (See Chapter XIV.) As plant-lice draw their nourishment from below the surface of the plants they infest, they are not injured by the application of poisons to the plants.

The Aphididæ comprises four sub-families; the following table for separating these sub-families is published by Dr. Thomas, in the Eighth Report of the State Entomologist of Illinois. It is necessary here to give the names applied to the veins of the wings, as some of them are used in this table. The principal vein of the front wing, that which extends from the base to near the tip of the wing, (Fig.

133, *sc*,) is the subcostal or submarginal vein. The distal end of this vein becomes widened, and extends to the margin of the wing; this part of it is the stigma (*st*). From the stigma, a curved vein extends to the tip of the wing; this is the stigmatic or fourth vein. From the submarginal vein there branch two or three veins (in addition to the stigmatic vein), which extend across the disk of the wing; these are the first, second, and third discoidal veins. The third discoidal vein is sometimes forked. The veins of the hind wing, so far as they are present, are named in a similar manner.

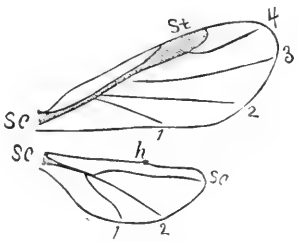

FIG. 133.—Wings of Plant-louse.

A. Winged form known; species not subterranean, except in a few cases where there are dimorphic forms.
  B. Front wings with three discoidal veins; antennæ of the winged individuals, and generally of the apterous individuals, six- or seven-jointed.
    C. Front wings with the third discoidal vein twice forked (except in Toxoptera, which, however, has well-developed honey-tubes); posterior wings with two discoidal veins; honey-tubes various. 4. APHIDINÆ.
    CC. Third discoidal vein with one fork or simple; posterior wings with one or two oblique veins; honey-tubes tuberculiform or wanting. 3. PEMPHIGINÆ.
  B. Front wings with but two discoidal veins, the third being absent; antennæ never more than five-jointed, sometimes but three-jointed. 2. CHERMESINÆ.
AA. Permanently apterous; at least no winged form has been observed: chiefly subterranean, residing on the roots of plants. 1. RHIZOBIINÆ.

Sub-Family I.—RHIZOBIINÆ.*

As indicated in the table above, this sub-family has been erected for certain genera in which no winged forms are known. It is possible that some of the insects placed here are merely the degraded wingless generation of species which have also higher developed forms with wings, and which pertain to some one of the three higher sub-families.

The *Rhizobiinæ* live in the ground upon the roots of plants. Our best known representative is the Lettuce Earth-louse, *Rhizōbius lactūcæ*. This occurs on the roots of lettuce, often in great num-

* Rhizobiinæ, Rhizobius; *rhiza* (ῥίζα), root; *bios* (βίος), life.

bers. The mature lice measure 2 mm. (0.08 inch) in length. They are oval, of a dull white color, with dusky legs and antennæ, and with the body dusted over with a white powder.

Other species of this sub-family are found on roots of grasses or herbaceous plants, and usually accompanied by ants.

Sub-Family II.—CHERMESINÆ.*

The *Chermesīnæ* includes those genera of plant-lice in which the front wings have only two discoidal veins; the antennæ are from three- to five-jointed.

This sub-family is represented by two common genera, *Chĕrmes* and *Phylloxēra*. In Chermes the antennæ are five-jointed, while in Phylloxera they are only three-jointed.

Chĕrmes.—The most common species of this genus is the Pine Blight, *Chĕrmes pinicŏrticis*. This, in its most conspicuous form, appears as patches of white, flocculent, down-like matter on the smooth bark of young white-pine trees. Beneath these patches of white substance the very minute young lice can be found. The winged generation appears in early summer. A closely allied species, *Chĕrmes abietĭcolens*, infests the terminal shoots of spruce, producing large swellings.

Phylloxēra.—This genus contains many species; one of them, *Phylloxēra vastātrix*, has attracted so much attention by the great extent of its ravages that it is often referred to as *the* Phylloxera. It is more properly termed the Grape Phylloxera. We have space for only a brief account of the history of this species.

FIG. 134.—Leaf of grape with galls of *Phylloxera*. (From Riley.)

The presence of this insect is manifested by the vines in two ways: first, in the case of certain species of grapes, there appear upon the lower surface of the leaves fleshy swellings, which are more or less wrinkled and hairy (Fig. 134); these are hollow galls, opening upon the upper surface

* Chermesīnæ, Chermes: Arab. *kermes*, Skt. *krimi*, a worm.

of the leaf, and containing a wingless agamic plant-louse and her eggs; second, when the fibrous roots of a sickly vine are examined, we find, if the disease is due to this insect, that the minute fibres have become swollen and knotty; or, if the disease is far advanced, they may be entirely decayed. Upon these root-swellings we also find an agamic, wingless, egg-laying plant-louse, the author of the mischief.

The insects found upon the roots differ slightly from those found within the galls; but their specific identity is now generally accepted. A careful study of this insect has revealed still other forms. So that now we can say that the species is presented to us under the three distinct forms described below.

Of the first form there are two types: one, the root-inhabiting type, which causes the knots on the roots; second, the gall-inhabiting type, which produces the galls upon the leaves. The gall-inhabiting type is simply a dimorphic form, which does not constitute an essential part in the cycle of changes through which the species must pass. It only appears when the insect infests certain species of grapes.

The following epitomized account of the life-history of this species is condensed from Dr. C. V. Riley's Sixth and Seventh Missouri Entomological Reports:

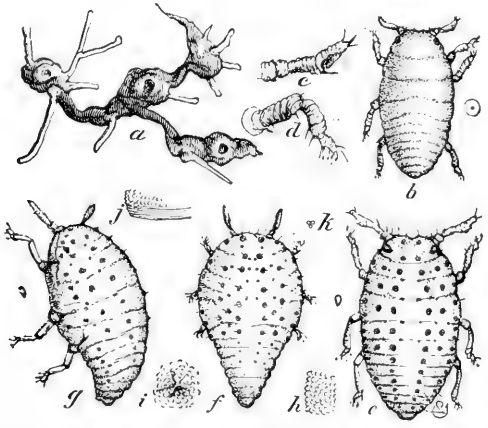

FIG. 135.—*Phylloxera* root-inhabiting form. *a*, roots of Clinton vine, showing the relation of swellings to leaf-galls, and power of resisting decomposition; *b*, larva as it appears when hibernating; *c*, *d*, antenna and leg of same; *e*, *f*, *g*, forms of more mature lice; *h*, granulations of skin; *i*, tubercle; *j*, transverse folds at border of joints; *k*, simple eyes. (From Riley.)

The Grape Phylloxera hibernates upon the roots of the grape, mostly as a young larva of the first or sedentary, agamic, wingless form (Fig. 135). With the renewal of vine-growth in the spring,

this larva moults, rapidly increases in size, and soon commences laying eggs. These in due time give birth to young, which soon become agamic, egg-laying mothers, like the first; and, like them, always remain wingless. Five or six generations of these parthen-

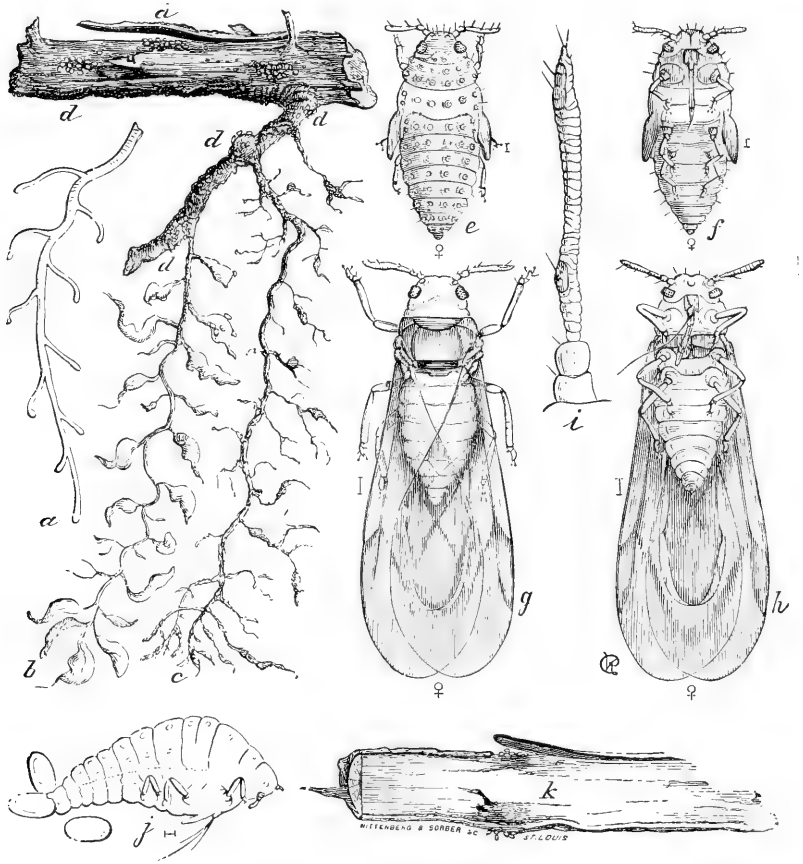

FIG. 136.—*Phylloxera*, root-inhabiting form. *a* shows a healthy root; *b*, one on which the lice are working, representing the knots and swellings caused by their punctures; *c*, a root that has been deserted by them, and where the rootlets have commenced to decay; *d*, *d*, *d*, shows how the lice are found on the larger roots; *e*, female nymph, dorsal view; *f*, same, ventral view; *g*, winged female, dorsal view; *h*, same, ventral view; *i*, magnified antenna of winged insect; *j*, side view of the wingless female, laying eggs on roots; *k* shows how the punctures of the lice cause the larger roots to rot. (From Riley.)

ogenetic, egg-bearing, wingless mothers follow each other, when (about the middle of July, in the latitude of St. Louis) some of the individuals begin to acquire wings. Thus is produced the second, or migrating, agamic, winged form (Fig. 136). These issue from the ground while yet in the pupa state; as soon as they have ac-

quired wings, they rise in the air and spread to new vineyards, where they lay their eggs, usually in the down of the under sides of the leaves. Each individual of this generation lays from three to five, and sometimes as many as eight eggs. These eggs are of two sizes; the smaller, which produce males, are about three-fourths the size of the larger, which produce females. From these eggs are hatched, in the course of a fortnight, the third, or wingless, sexual form. It is a very remarkable fact that this form emerges from the egg not as larvæ but as fully developed individuals. These sexual individuals are born for no other purpose than the reproduction of their kind, and are without means of flight, or of taking food. After pairing, the body of the female enlarges somewhat and she is soon delivered of a solitary egg. This impregnated egg gives birth to a young louse, which develops into the first or sedentary, agamic, wingless form; and thus recommences the cycle of changes through which the insect passes.

It has been discovered that sometimes the first form, during the latter part of the season, lays a few eggs, which are of two sizes, like those of the second form, and like those also produce males and females. These males and females are precisely like those born of the winged form, and like them produce the solitary impregnated egg. Thus the interesting fact is established that even the winged form is not essential to the perpetuation of the species.

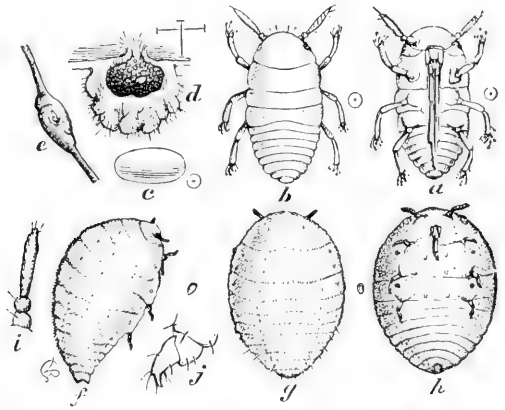

FIG. 137.—*Phylloxera*, gall-inhabiting form. *a*, *b*, newly hatched nymph, ventral and dorsal view; *c*, egg; *d*, section of gall; *e*, swelling of tendril; *f*, *g*, *h*, mother gall-louse, lateral, dorsal, and ventral views; *i*, her antenna; *j*, her two-jointed tarsus. Natural sizes indicated at sides. (From Riley.)

If to the above account we add that occasionally individuals abandon their normal underground habit, and form galls upon the leaves of certain varieties of grape-vine (Fig. 137), we have, in a general way, the whole natural history of the species.

Owing to the great injury which the species has done to the vineyards of France, hundreds of memoirs have been published regarding it. But, as yet, no satisfactory means of destroying it has been discovered. The difficulty lies in the fact that the insecticide must be one that can penetrate the ground to the depth of three or four feet, reaching all of the fibrous roots infested by the insect. It must be a substance that can be cheaply applied on a large scale; and it must also be something that will kill the insect without injury to the vine.

Where the vineyards are so situated that they can be submerged with water for a period of at least forty days during winter, the insect can be drowned. But this method is obviously of limited application.

It is found that vines growing in very sandy soil resist the attacks of the Grape Phylloxera. This is supposed to be due to the difficulty experienced by the insect in finding passages through such soil.

The method of destroying the pest which is most generally available is by the use of carbon bisulphide. See Chapter XIV.

Sub-Family III.—PEMPHIGINÆ.*

The *Pemphigīnæ* includes those genera of plant-lice in which the front wings have three discoidal veins, and of which the third discoidal vein has only one fork or is simple; the honey-tubes are tuberculiform or wanting.

In habits and transformations it is an unusually interesting group. As a rule the species live above ground, although with some there are root-inhabiting forms. Many species are remarkable for the form and abundance of their excretions; others cause abnormal vegetable growths or galls within which they live. The galls made by the different species vary greatly in form; but each species produces a characteristic gall.

The species chosen to illustrate this sub-family represent two sections of it, as indicated below:

Section I.—PEMPHIGINI.

This section includes genera in which the third discoidal vein of the front wings is simple; the antennæ are six-jointed.

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* Pemphigīnæ, Pemphīgus: *pemphix* (πέμφιξ), a blister.

Three genera occur in this country. These can be distinguished as follows:

A. Hind wings with two discoidal veins.	1. PEMPHIGUS.
A A. Hind wings with only one discoidal vein.	
B. Antennæ six-jointed.	2. TETRANEURA.
BB. Antennæ five-jointed.	3. HORMAPHIS.

Among the common representatives of this section are certain species of *Pemphigus*, which make galls upon various trees of the genus *Populus*. One of these, the Poplar-leaf Gall-louse, *Pemphīgus populicāulis*, is common on the leaves of cotton-wood and of aspen. It makes a swelling the size of a small marble on the leaf at the junction of the petiole with the blade. This gall is of a reddish tint, and has on one side a slit-like opening. In the early part of the season each gall is occupied by a single, wingless female, probably the agamic stem-mother, which, by midsummer, becomes the mother of numerous progeny; these often amount to one hundred and fifty in number.

A closely allied species occurs throughout the Western and Southwestern States, which makes a similar gall near the base of the leaf of Populus monolifera and P. balsamifera. This gall has a transverse slit-like opening, which probably suggested the name of the insect, *Pemphīgus pŏpuli-transvĕrsus*. As in the preceding species, the gall is started in the spring by a single, wingless stem-mother; by the latter part of June the stem-mother is surrounded with young of various sizes, all covered with the usual white secretion, and mixed with liquid globules. A generation of winged individuals is produced in the autumn, sometimes not until the leaves have fallen.

Another of these species is known as the Vagabond Gall-louse, *Pemphīgus vagabŭndus*. It infests the tips of the twigs of certain cotton-woods and the balsam poplar; here it makes large corrugated galls, which somewhat resemble the flower of the double cockscomb of our gardens. These galls turn black, and remain on the trees during the winter. On opening the galls in midwinter I have found many remains of winged lice in them.

Section II.—SCHIZONEURINI.

This section includes genera in which the third discoidal vein of the front wings is forked; the antennæ are six-jointed. Two genera

occur in this country, *Colopha* and *Schizoneura*. In *Colopha* the hind wings have only one discoidal vein; in *Schizoneura* they have two.

The Cockscomb Elm Gall, *Cŏlopha ulmĭcola*.—Among the gall-making species of this section this is probably the most familiar one. The gall is an excrescence or follicle like a cock's comb, which rises abruptly from the upper surface of the leaves of elm; it is usually about an inch long and a quarter of an inch high; it is compressed, and has its sides wrinkled perpendicularly and its summit irregularly gashed and toothed; it is of a paler green color than the leaf and more or less red on the side exposed to the sun; it opens on the under side of the leaf by a long slit-like orifice; inside, it is wrinkled perpendicularly into deep plaits. The complete life-history of this species is not known. According to Riley and Monell there is a winter egg, which is usually inclosed in the dry skin of a sexual female. This can be found during winter in the crevices of the bark of the White Elm. The stem-mother which hatches from this egg forms the gall. She gives birth to numerous offspring; these become winged, and constitute the only generation produced within the gall. These winged, agamic females issue from the slit-like opening of the gall; and each gives birth in the course of a day or so to upwards of a dozen young. These are born as pseudova. They have well developed mouth-parts; and it is probable that when fully grown they give birth to the sexual generation.

To the genus *Schizoneura* belong several of our most conspicuous "Woolly Aphids." Among them are the following:

The Alder Blight, *Schizonēūra tessellāta*.—This woolly louse is often found crowded together on the under side of the branches of alder (*Alnus rubra*), and concealed beneath a covering of downy excretion. It also excretes abundantly honey-dew. The result is that the branches infested by this insect, and those beneath the cluster of Aphids, become blackened with fungi that grow upon this secretion. There is also a curious fungus which grows in large spongy masses immediately beneath the cluster of plant-lice; this is known to botanists as *Scorias spongiosum*. It is evidently fed by the honey-dew that falls upon it.

The Beech-tree Blight, *Schizonēūra imbricātor*.—This infests both the twigs and leaves of beech. Like the preceding species it occurs in clusters of individuals, each of which is clothed with a conspicuous downy excretion. These clusters often attract attention by the curious habit which the insects have of waving their bodies up and down, the plume-like masses of excretion rendering them very

conspicuous. When an infested limb is jarred, the Aphids emit a shower of honey-dew. Owing to the abundance of this secretion, the branches and leaves of an infested tree become blackened by growths of fungi, as with the preceding species.

The Woolly-louse of the apple, *Schizoneūra lanïgera*.—The Woolly-louse of the apple is one of the best known pests of the fruit-grower. In its most conspicuous form it appears on the trunk and limbs of apple-trees. It congregates in clusters of individuals, which are conspicuous on account of the woolly excretion with which their bodies are clothed. They are especially injurious to young trees, the bark of which becomes deeply pitted and scarred by their attacks. The bark apparently ceases to grow at the point of attack, but swells into a large ridge about the cluster of lice, leaving them in a sheltered pit. The lice also frequently congregate in the axils of the leaves and the forks of the branches. This species resembles the grape Phylloxera in having a root-inhabiting form, which causes knotty swellings on the fibrous roots. It is the presence of this form which makes this pest such a difficult one to combat.

Although this insect has been known since the close of the last century, its complete life-history has not been traced out. As with all the Pemphiginæ the transformations of which we know, and with Phylloxera, there is in this species a generation of mouthless, wingless, and generally degraded sexual individuals. The females of this generation produce each a winter egg. This can be found in the winter in the crevices of the bark, and in the pits caused by the trunk form. It is frequently enveloped in the dry skin of the sexual female. The trunk type at least of the wingless, agamic form gives birth to living young not enveloped in a pellicle. As the season advances there appears a generation of winged individuals. These are probably agamic; but whether they produce the sexual generation directly or whether there intervenes one or more agamic generations has not been determined. At Washington I have seen both the root and trunk type of the wingless, agamic form maintain themselves throughout an entire winter without the intervention of a winter egg. I presume this is a common occurrence farther south.

As one form of this insect works deep in the ground upon the fibrous roots of the trees, the same difficulties are met in attempting to destroy it that are presented by the grape Phylloxera. In fact, except in case of an especially valuable tree, I do not believe that it will pay to attempt to save a tree that has become badly infested by the woolly aphis. It will be cheaper to dig the tree up and burn it,

and devote the ground to some other use. Some other species of tree can be safely planted in the same place, but not an apple. Great care should be taken in putting out trees from a nursery to see that they are free from this pest. If there is any doubt, the trees should be washed, roots and all, in a strong solution of soap. It is well also to put in the fork of the trees a piece of hard soap, which will be dissolved and washed down by the rains. This will serve to prevent certain other pests as well as the woolly aphis from getting a foothold. In case it is desired to rid an infested tree of this pest, the trunk form should be washed off with a strong solution of soap applied with a sponge, taking care to destroy all eggs; and the ground should be treated with carbon bisulphide, as for the grape Phylloxera.

Sub-Family IV.—APHIDINÆ.

The sub-family Aphidinæ includes those genera in which the third discoidal vein of the front wings is twice forked; the hind wings have two discoidal veins; and the honey-tubes are usually well developed, sometimes tuberculiform or obsolete. The number of species belonging to this group is very great; it being the largest of the sub-families of the Aphididæ. Most of the species live above ground, on the surface of leaves or twigs of woody plants or upon the leaves and stems of the more succulent species. I do not know of any species that produce galls.

Lăchnus.—The largest of our species of Aphididæ belong to the genus *Lachnus*. *L. cāryæ* is found on the pig-nut hickory, clustered on the under side of the limbs in summer; it is interesting from being perhaps our largest plant-louse, measuring to the tip of the abdomen 6 mm. (0.24 inch), and more than 10 mm. (0.4 inch) to the tip of the wings.

FIG. 138.—*Lachnus.*

Āphis.—To the genus *Aphis*, in its restricted sense, belong a considerable number of the important species of this sub-family. The species that occurs in such immense numbers on cabbage is *Aphis brassicæ*. It is the most common, and, perhaps, the most injurious species that occurs in the vegetable gardens of this country. The Corn Plant-louse is *Aphis maidis*. This species, according to the observations of Forbes, winters in the wingless, agamic form in the earth of fields previously infested. In the spring it appears to be strictly dependent upon a species of ant, *Lasius alienus*, which mines along the principal roots of the corn, collects the plant-lice, and

conveys them into these burrows, and there watches and protects them. In a short time after the lice have been transferred to the roots of the corn, they mature a winged generation, by means of which adjacent fields may be stocked. These facts indicate the inadvisability of planting corn on a field that was infested by this insect the previous year. The species of *Aphis* that has attracted the most attention recently is *Aphis māli.* This has occurred in immense numbers on the young leaves of apple. Usually the injuries of this species are confined to the terminal shoots of a few branches; but in seasons favorable to its development, the entire tree becomes infested. It is necessary then to resort to the use of alkaline washes. (See Chapter XIV.)

Mȳzus.—Two species of Myzus are very common. One of these, the Cherry-tree Aphis, *Myzus cĕrasi*, infests the leaves and twigs of cherry. Sometimes it becomes so abundant that it completely covers the infested tree. The other species referred to is the Peach-tree Aphis, *Myzus persicæ.* This lives on the under side of the leaves, causing them to thicken and curl. Its injuries are usually confined to the terminal portion of a few branches. The easiest way to destroy this pest is to dip the infested branches into a pail of soap solution. There is a serious disease of the peach which causes the leaves to curl in a similar manner, and which is known as the curl-leaf. This disease can be distinguished from the injuries of the Peach-tree Aphis by the absence of plant-lice in the curled leaves. It is caused by a fungus known as *Exoascus deformans.*

The Hop Aphis, *Phŏrodon hūmuli.*—This species often swarms in hop-yards to such an extent that it seriously injures the crop. An interesting and important feature in its life-history is that it passes the winter on plum-trees. As soon as the leaves of plum appear in the spring, the first generation of this Aphid hatches from the winter eggs on plum. The first and second generations are wingless, agamic females, which live upon the plum; the third appears early in June, is winged, and migrates to the hops. From this generation there descend several generations of wingless, agamic females. Of these there may be, according to Riley's observations, upon which this account is based, as many as eight, making the last one the eleventh of the season. Late in August and early in September the offspring of the eleventh generation and of the members of the other generations that are still alive become winged. These winged individuals are agamic females which migrate to plum-trees and there produce wingless, sexual females. Late in September, there is produced on

the hops by some members of the eleventh agamic generation a generation of winged males. These fly to the plum-trees and mate with the wingless sexual females, which are already there. Soon after this the eggs are deposited on the smaller twigs and branches of the plum, in and around the angles formed by the buds and twigs. Each female lays from one to three eggs.

If it should be proven that this species can winter only on plum, the separation of plum and hop culture would be advisable. But further observations are needed before we are warranted in advising the destruction of plum-trees in the hop-growing sections. But we can urge the careful destruction of all Aphids on plum-trees early in the season. The most practicable way of doing this is by spraying with a strong solution of soap or with kerosene emulsion. (See Chapter XIV.)

Family V.—Psyllidæ.*

(*Jumping Plant-lice.*)

The Jumping Plant-lice are comparatively small insects; our more common species measure only 3 or 4 millimeters in length; and our largest species, the giant, comparatively speaking, measures only 6 mm. and has a wing-expanse of 12 mm. They resemble somewhat the winged Aphids in appearance; but they look more like miniature Cicades (Fig. 139). They are, however, closely allied to the Aphids; but they differ from them in the firmer texture of the body, in the stouter limbs, in having the hind legs fitted for jumping, and in the 9- or 10-jointed antennæ. The antennæ are peculiar also in being armed at the tip with two bristles, or less commonly with one. "The rostrum is short, three-jointed, and placed almost between the fore coxæ, where it fits into a grooved space. Both sexes are always winged in the adult; the wing-covers are ample, and, while often transparent, are much thicker than the wings, and furnished with stout curving veins, which enclose a few areoles at the tip." (Uhler.)

Fig. 139.—*Psylla*, enlarged.

The Psyllidæ subsist entirely upon the juices of plants; many species form galls. But it is rare that any of them appear upon cultivated plants in sufficient numbers to attract attention, except in case of the Pear-tree Psylla.

* Psȳllidæ, Psylla: *psylla* (ψύλλα), a flea.

The Pear-tree Psylla, *Psylla pyri.*—This is a minute species which measures only 2.5 mm. (0.1 inch) to the tip of the folded wings. It invests the smaller limbs and twigs of pear-trees, causing them to droop and fall off. It can be destroyed in the same way as recommended for plant-lice in the same situation.

Family VI.—MEMBRACIDÆ.*

(*Tree-hoppers.*)

We have many common representatives of this sub-family; and the grotesque forms of certain species are sure to attract the attention of collectors. The general outline of the body is usually triquetral, that is, shaped like a beech-nut. But many of the species have one or more of the angles prolonged, or are furnished with prominent humps or tubercles. The most useful character for distinguishing members of this family is the prolongation of the prothorax backward above the abdomen. Sometimes it extends back to the tip of the abdomen, and completely covers the wings. This development of the prothorax reminds us of what occurs in the Tettiginæ, of the order Orthoptera.

Many species of the Membracidæ live upon bushes or small trees; and all are good leapers. Hence the common name, Tree-hoppers. Although these insects subsist upon the juices of plants, I have never known them to occur in sufficient numbers to be of economic importance. Some members of this family excrete honey-dew, and are attended by ants, as are the Aphids. The transformations of but few species have been observed. Some of these make slits in twigs, in which they lay their eggs. The immature forms of certain species occur upon plants in company with the adults. But the early stages of the great majority of species are unknown to us.

The genus *Darnis* will serve as a good illustration of one of the principal types of this family. Here the prothorax is nearly all that can be seen of the body from above. It is very convex in front, overshadowing the short, transverse, band-like head, and tapers to a sharp point, which extends beyond the tip of the abdomen. (Fig. 140.)

FIG. 140. *Darnis.*

The Buffalo Tree-hoppers, *Cerēsa būbalus*, represents another type belonging to this family. The popular name refers to the lateral prolongations of the prothorax, which suggest the horns

* Membrăcidæ, Membrācis: *membrax* (*μέμβραξ*), a kind of Cicada.

of a buffalo (Fig. 141). This insect lives on the sap of apple, pear, and other trees. It is of a yellowish-green color. The eggs are laid in little slits in the bark; they hatch in the spring; and the young are very different from the adult, being furnished with a pair of large spines upon each segment.

FIG. 141.—*Ceresa bubalus.*

The Two-horned Tree-hoppers, *Cerēsa diceros*, is also a common species. It resembles the Buffalo Tree-hopper in size and form. It is a pale, dirty yellow, spotted with brown; the lateral and caudal aspect of each horn is brown; the caudal tip of the prothorax, and a large spot midway between the tip and horns are also brown. The insect is densely clothed with hairs.

The genus *Enchenōpa* illustrates another strange form found in this family. The Two-marked Tree-hopper, *Enchenopa binotāta*, (Fig. 142,) abounds on various trees, shrubs, and herbaceous plants. It is gregarious; and both adult and immature forms are found clustered together. It is almost always attended by ants. It lays its eggs in frothy masses, which are very white, and appear like wax. These egg-masses have been mistaken for insects of the genus *Orthezia*. Another very common species is *E. curvāta*. It is brownish, unspotted, and has a rather longer horn than the preceding species.

FIG. 142.—*Enchenopa binotata.*

"To the genus *Telamōna* (Fig. 143) belong our indigenous humpback forms, of gray, claret, or greenish colors, which live in June and July upon oaks, hickories, and other forest trees. They generally rest singly on the limbs and branches of the trees, with the head directed away from the trunk; but in the younger stages they keep together in small groups." (Uhler.)

FIG. 143.—*Telamona.*

Family VII.—CICADIDÆ.*

(*Cicadas.*)

The large size and the well-known songs of the more common species of this family render them familiar objects. It is only necessary to refer to the Periodical Cicada (or the 17-year locust, as

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* Cicadidæ, Cicada: *Cicāda*, Latin name of these insects.

it has been improperly termed) and to the Dog-day Harvest-fly (Fig. 144) to give an idea of the more striking characters of this family.

The species are generally of large size, with a subconical body. The head is wide and blunt, with prominent eyes on the outer angles, and three bead-like ocelli arranged in a triangle on the vertex. "The mesothorax is the largest segment, and the metathorax is reduced to a narrow scale. A very conspicuous feature in all of them is a cross-like prominence on the hind end of the former, which adds great firmness to this important part of the chest. The wing-covers are nearly elliptical, longer than the body, parchment-like, but generally transparent, and with a series of eight areoles at the tip; but the hind wings are more membranous, scarcely exceeding half the length of the former, and with an apical series of six areoles. Their legs are short and stout, not fitted for leaping, the fore-thighs quite thick, armed with two or more thick teeth; also, the hind shanks are bristly, and have a series of sharp spines on each side.

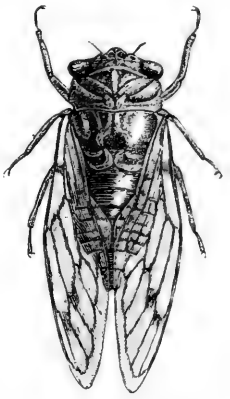

FIG. 144.—*Cicada tibicen.*

"But the most distinctive peculiarity, which has no parallel in any of the other groups, appears in the organs of sound (of the males). These consist of two large parchment sacs, ribbed and gathered into numerous plaits, furnished with powerful muscles, and situated in large cavities at the base of the abdomen. When in action, the air is driven in great force against the ribbed surfaces, and vibrations are set up which produce the sound in accordance with the number and form of the fluted spaces and ribs." (Uhler.)

The Dog-day Harvest-fly, or Lyerman, *Cicāda tibīcen.*—The shrill cry of this species, which is the most prominent of the various insect sounds heard during the latter part of the summer, has brought its author into prominent notice. This insect varies both in size and colors. It commonly measures 50 mm. (2 inches) to the tip of the closed wings; it is black and green, and more or less powdered with white beneath. The transformations of this insect are similar to those of the following species, except that it requires only two years for its development. It differs also in seldom, if ever, occurring in sufficient numbers to be of economic importance; but a

brood of it appears each year. It is distributed from New York to Rio de Janeiro.

The Periodical Cicada, *Cicāda septĕndecim.*—This species is now commonly known as the 17-year locust. But the term locust, as applied to it, is a misnomer, the locusts being Orthopterous insects. I therefore adopt the more appropriate name, Periodical Cicada, which has been proposed for it. This species is remarkable for the long time required for it to attain its maturity. The eggs are laid in the twigs of various trees; the female makes a series of slits in the twig, into which the eggs are placed. Sometimes this Cicada occurs in such great numbers that they seriously injure small fruit-trees, by ovipositing in the twigs and smaller branches. The larvæ hatch in about six weeks. They soon voluntarily drop to the ground, where they bury themselves. Here they obtain nourishment by sucking the juices from the roots of forest and fruit trees. And here they remain till the seventeenth year following. They emerge from the ground during the last half of May, at which time the empty pupa-skins may be found in great numbers, clinging to the bark of trees and other objects. The insects soon pair, the females oviposit, and all disappear in a few weeks.

More than twenty distinct broods of this species have been traced out; so that one or more broods appear somewhere in the United States nearly every year. In many localities, several broods coexist; in some cases there are as many as seven distinct broods in the same place, each brood appearing in distinct years. There is a variety of the species in which the period of development is only thirteen years. This variety is chiefly a Southern form, while the seventeen-year broods occur in the North.

Family VIII.—Fulgoridæ.*

(*Lantern-flies et al.*)

This family is remarkable for certain exotic forms which it contains. Chief among these is the great Lantern-fly of Brazil, which is figured in many popular works on insects. Scarcely less strange are the Candle-flies of China and the East Indies. There does not seem

* Fulgŏridæ, Fulgōra: *fulgor*, flashing lightning.

to be any typical form of the body, characteristic of this family. The different genera differ so greatly that, on superficial examination, they appear to have very little in common. Some even resemble butterflies and moths, while others might easily be mistaken for certain Neuropterous genera.

The most useful character for recognizing these insects is the form and position of the antennæ. These are bristle-shaped, and inserted into a button-shaped base on the sides of the cheeks beneath the eyes. Although the Fulgoridæ are vegetable-feeders, none of our species have attracted the attention of agriculturists. There are, however, certain exotic species which do great injury to crops.

The Brazilian Lantern-fly, *Laternāria phosphōrea.*—This is the largest species of the family, and is one of the most striking in appearance of all insects. It has immense wings, expanding nearly 150 mm. (6 inches). Upon each hind wing there is a large eye-like spot. But the character which makes this insect especially prominent is the form of the head. There is a great bladder-like prolongation extending forwards. This prolongation has been aptly compared to the pod of a peanut. In a specimen before me, the body, exclusive of the head, measures 45 mm. (1.8 inches) in length; while the head alone measures 30 mm. (1.2 inches). The specific name refers to the supposed luminosity of this part. Prof. Branner tells us of various superstitions held by the Brazilians regarding this insect. For example: "That it has great powers of flight, and when in its wild career it strikes any living object—if an animal, no matter how large or powerful—it falls dead upon the spot; if a tree, it soon wilts and dies."

The Chinese Candle-fly, *Fulgōria candelāria.*—This is another very prominent insect, and also one that has the reputation of being phosphorescent. It is commonly represented in collections of exotic insects, and it is often figured by the Chinese. It is smaller than the preceding species, measuring about two thirds as much in length. The prolongation of the head is proportionately longer than in the Brazilian insect; but it is more slender, and is conical. The color of the insect is greenish or orange-yellow, with banded wing-covers.

The following of our native genera will serve to illustrate some of the variations in form represented in this country. Our species are all small compared with the exotics described above.

Scōlops.—In this genus the head is greatly prolonged (Fig. 145), as with the exotic Candle-flies. Our more common species, however, measure only about 8 mm. (0.31 inch) in length.

FIG. 145.—*Scolops.*

Otiŏcerus.—In this genus, the body is oblong; the head is compressed, with a double edge both above and below, and the antennæ are furnished with tape-like appendages. "*Otiŏcerus coquebĕrtii* is a gay lemon-yellow or cream-colored species, with a broad stripe on the side of the face and wavy red forked lines on the wing-covers; the head, as seen from the side, is of the form of a ploughshare, with little brown eyes standing out like beads. The antennæ have three bent appendages resembling strips of tape. It measures about 8 mm. (0.3 inch) to the tip of wing-covers, lives upon the leaves of grape-vines, oaks, and hickory, in July, August, and September." (Uhler.) It is distributed over the entire Eastern United States.

Ormenis.—In our common representatives of this genus the wing-covers are broad, and closely applied to each other in a vertical position; they are more or less truncate, and give the insect a wedge-shape outline. *O. septentrionālis* (Fig. 146) is a beautiful pale-green species powdered with white, which feeds on wild grape-vines, drawing nourishment from the tender shoots and mid-ribs of the leaves, during its young stages.

FIG. 146.—*Ormenis septentrionalis.*

Family IX.—CERCOPIDÆ.*

(*Spittle-insects or Frog-hoppers.*)

This and the following family agree with the Membracidæ in having the antennæ inserted in front of and between the eyes. But the Cercopidæ differs from the Membracidæ in lacking the backward prolongation of the prothorax, and from the Jassidæ in the character of the spines upon the hind tibiæ. Here we find the tibiæ armed with one or two stout teeth, and the tip crowned with short, stout spines. The Cercopidæ "mark an important advance in the direction of the Heteroptera by the large size of the prothorax and increased freedom of the fore legs. This extensive piece is no longer a mere cap or

* Cercŏpidæ, Cercopis: *Cercops* (*Κέρκωψ*), one of a fabled race of men.

scale as in most of the Fulgoridæ, nor yet a lid, case, or bubble-like expansion as in the Membracidæ, but is an important regional portion, exercising various important functions." (Uhler.)

Our most common representatives of the family are the insects known as spittle-insects or frog-hoppers. During the summer months one often finds upon various shrubs and herbs masses of white froth. In the midst of each of these masses there lives a young insect, a member of this family. In some cases as many as four or five insects inhabit the same mass of foam. The froth is supposed to consist of sap, which the insect has pumped from the plant, by means of its rostrum, and passed through its alimentary canal. It is asserted that these insects undergo all their transformations within this mass; that when one is about to moult for the last time, a clear space is formed about its body; the superficial part of the foam dries, so as to form a vaulted roof to a closed chamber within which the change of skin is made. The adult insects wander about on herbage and trees. They have the power of leaping well. The name frog-hoppers has doubtless grown out of the fact that formerly the froth was called "frog-spittle," and was supposed to have been voided by the tree-frogs from their mouths. The name is not, however, inappropriate; for the broad and depressed form of our more common species is something like that of a frog.

Our more common species of spittle-insects belong to the genus *Aphrŏphora*. They are mostly brownish insects, and are variously banded and spotted. One of the common species of the Eastern United States is *Aphrŏphora quadrangulāris* (Fig. 147). The adult of this species is a brownish insect, densely covered with microscopic hairs, and black beneath; the wing-covers are marked with two oblique, brown bands, which are confluent near the middle of the costal margin; the humeral region is dusky; and the tip of each wing-cover is marked with a small blackish curve; the ocelli are black, but indistinct. This species measures from 6 mm. to 8 mm. (0.24 to 0.31 inch) in length. Somewhat resembling this species, and also common in the East, is *Aphrŏphora quadranotāta*. In this species the body is pale; the wing-covers are dusky, each with two large hyaline costal spots, margined with dark brown; the ocelli are blood-red; and the head and pronotum are furnished with a slightly elevated, median, longitudinal line.

FIG. 147.—*Aphrophora quadrangularis.*

To the genus *Clastŏptera* belong certain other common members

of this family. In this genus the body is short and plump, sometimes nearly hemispherical; the species are small, our common forms ranging from 3 mm. to 6 mm. (0.12 to 0.24 inch) in length. *Clastŏptera prōteus* is a conspicuous species on account of its bright yellow markings. It varies greatly in color and markings; but the most striking forms are black, with three transverse yellow bands, two on the head and one on the thorax; and with the scutellum and a large oblique band on each wing-cover yellow. Another common species is *Clastŏptera obtūsa*. This occurs on black alder in summer and autumn. "It is of a claret-brown color above, marked with two pale bands on the vertex, two on the prothorax, and a wavy, broader band on the wing-covers. The membrane is often whitish, the waved band is extended exteriorly, and there is a pale V-shaped figure on the end of the scutellum."

Family X.—Jassidæ.*

(*Leaf-hoppers.*)

This the highest family of the Homoptera is a very extensive one. And it is also of considerable economic importance; for it includes a number of species that are very injurious to vegetation. The body is more slender than in the preceding family; with which this agrees in the insertion of the antennæ in front of and between the eyes, and in the absence of a prolongation of the prothorax above the abdomen. But the most salient character which distinguishes the Jassidæ is the structure of the hind tibiæ. These are nearly or quite as long as the abdomen, curved, and armed with a row of spines on each margin. The form of the body "is commonly long and slender, often spindle-shaped, with a large transverse prothorax not much wider than the head. The front is generally an oblique, cross-ribbed, inflated prominence, with the cheeks touching the anterior coxæ, but rarely, if ever, restraining their movement. They have a rather large triangular scutellum; the wing-covers curve over the sides of the abdomen, appear as tapering towards the tip, and the membrane is distinguished from the more leathery corium." (Uhler.)

The Jassidæ are able to leap powerfully; and, as they are more often found on the leaves of herbage and on grass than elsewhere, they have been termed leaf-hoppers.

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* Jăssidæ, Jăssus: *Jassus*, a proper name.

The family has been divided in various ways by different writers. It seems best to recognize in this place only two sub-families; although seven are proposed by Stal. These two sub-families can be distinguished as follows:

A. Ocelli placed on the front rim of the vertex close to the eyes, or on the front, but never on the disk of the vertex. I. JASSINÆ.
AA. Ocelli placed upon the vertex. II. TETTIGONINÆ.

Sub-Family I.—JASSINÆ.

The more important members of the Jassinæ from an economic standpoint are the following:

The Destructive Leaf-hopper, *Cicădula exitiōsa.*—During the winter of 1879–80 much damage was done to winter grain in the Carolinas and Georgia by this species. It is a small, active, brownish insect, which measures with its wings folded about 5 mm. (0.2 inch) in length. Its general form is well indicated by the enlarged figure (Fig. 148). It is very quick, a good flyer, and a great jumper. It injures grass or grain by piercing the midrib of the leaf and sucking the juices from it. Upon the plantation where I studied this insect there was observable a most exact line between the eaten and uneaten portions of the wheat-field. Instead of spreading themselves over the field indiscriminately, or half eating a patch here and there, the leaf-hoppers ate the wheat down to the ground as they progressed. They are very shy, however, and fly away on the least disturbance. Judging from the known habits of allied species, the eggs are doubtless laid in the stems of grasses close to the ground. The young hoppers when hatched are almost precisely of the same appearance as the old ones, except that they lack wings. The time occupied in attaining full growth probably does not exceed a month, so that there are several broods a year. These insects are readily attracted by light; and probably many of them could be destroyed by trap-lanterns, or by building bonfires at night. It is possible, also, that many could be destroyed by spraying with some of the alkaline or other washes described in the chapter on remedies. In those cases where the line of injury is a well-marked one, only a small part of the field would need to be sprayed.

FIG. 148.—*Cicadula exitiosa.* (From the Author's Report for 1879.)

The Grape-vine Leaf-hopper, *Erythronēura vītis.*—There are

several species of Leaf-hoppers that infest the leaves of grape, and are known to grape-growers as the "Thrip." These all belong to the genus *Erythroneura*. The most common one is *E. vītis*. It is a little more than 3 mm. (0.12 inch) in length, crossed by two blood-red bands, and a third dusky one at the apex. These insects pass the winter in the perfect state, hibernating under dead leaves or other rubbish; in the spring they deposit their eggs on the young leaves of the vine. The larvæ hatch during the month of June, and resemble the adult insect except in size and in being destitute of wings. The insects feed together on the under side of the leaves, and are very quick in their movements. Like the preceding species this insect can be destroyed by trap-lanterns or by washes.

The Rose Leaf-hopper, *Ĕmpoa rōsæ*.—"Swarms of these insects may be found, in various stages of growth, on the leaves of the rose-bush, through the greater part of the summer, and even in winter upon housed plants. Their numerous cast skins may be seen adhering to the lower sides of the leaves. They pair and lay their eggs about the middle of June, and they probably live through the winter in the perfect state, concealed under fallen leaves and rubbish on the surface of the ground." Although this is a very common pest, it does not seem to have received much attention from entomologists since the time of Harris, from whom the above account is quoted. It should be combated in the same way as the leaf-hoppers already described.

Sub-family II.—Tettigoninæ.*

The members of this sub-family are mostly small or medium-sized insects, with long narrow bodies. But we find here some forms which resemble certain genera belonging to the Cercopidæ. Thus *Penthĭmia* includes plump, short-bodied insects, which remind us of *Clastŏptera;* and the genus *Gypona* includes a large number of species, some of which resemble very closely certain species of *Aphrophora*. It is, however, hardly necessary to remind the student that a glance at the posterior tibiæ of these leaf-hoppers will enable one to distinguish them from the Cercopids, which they so closely resemble.

The genus *Diedrocĕphala* includes grass-green, or pale-green, spindle-shaped species which represent better the typical form of this sub-family. The members of this genus may be recognized by the long, triangular head as seen from above. One of the species,

* Tettigonīnæ, Tettigonia : *tettix* (τέττιξ), a cicada; *gonia* (γωνία), a corner.

D. flăviceps, sometimes greatly injures fields of grain in the South. The most common species in New York is *D. noveboracĕnsis*.

The genus *Procōnia* includes species in which the head is more blunt than in the preceding genus, and is wider across the eyes than the thorax. *P. undāta* (Fig. 149) is a common species. "Its body, head, fore part of thorax, scutellum, and legs are bright yellow, with circular lines of black on the head, thorax, and scutellum. The underside of the abdomen is banded, and the breast and legs speckled with black. The wing-covers are bluish purple, when fresh, coated with whitish powder." (Uhler.) It measures 12 mm. (0.47 inch) to the tip of the wing-covers. It is said to lay its eggs in single rows in grape canes; and to puncture with its beak the stems of the bunches of grapes, causing the stems to wither and the bunches to drop off.

FIG. 149.—*Procōnia undata.*

Sub-Order III.—HETEROPTERA.*

The Heteroptera includes those members of the order Hemiptera to which the general name Bug is most frequently applied. These insects are characterized, as already indicated, by having the first pair of wings thickened at the base, and with thinner extremities, which overlap on the back; and by the position of the rostrum, which arises from the front part of the head. The head is furnished with a more or less distinct neck, so that the cheeks and the first pair of coxæ do not touch each other.

In this sub-order we find variations in structure which correspond closely with variations in habits. There are certain families the members of which are truly aquatic, living within the water, through which they swim, and to the surface of which they come occasionally for air. There are others which are truly terrestrial, living upon the surface of plants, or in other positions away from water. There are still other families the members of which hold an intermediate position between the aquatic and the terrestrial forms, living upon the surface of water, or in marshy places.

In a systematic arrangement of the Heteroptera the aquatic forms are placed first or lowest; the terrestrial forms, highest; and the semiaquatic forms hold an intermediate position.

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* Heterŏptera: *heteros* (ἕτερος), diverse; *pteron* (πτερόν), a wing.

TABLE FOR DETERMINING THE FAMILIES OF HETEROPTERA.

A. Antennæ short, and nearly or quite concealed beneath the head.
  B. Ocelli wanting; insects aquatic, and, excepting Nepidæ and Naucoridæ, with legs fitted for swimming.
    C. Head overlapping the prothorax; fore tarsi flattened, consisting of one segment, and ciliated. Fam. XI.—CORISIDÆ.
    CC. Head inserted in the prothorax; fore tarsi normal.
      D. Body thick, dorsal aspect of abdomen very convex. Insects which swim upon their back. Fam. XII.—NOTONECTIDÆ.
      DD. Body either flat or elliptical in outline, or much elongated; caudal end of abdomen furnished with a respiratory tube composed of a pair of grooved filaments. Fam. XIII.—NEPIDÆ.
      DDD. Body flat, oval or ovate, without respiratory filaments.
        E. Abdomen with a pair of strap-like caudal appendages (these appendages are retractile, and are frequently withdrawn from sight); legs flattened for swimming. Fam. XIV.—BELOSTOMATIDÆ.
        EE. Abdomen without caudal appendages; legs fitted for crawling rather than swimming. Fam. XV.—NAUCORIDÆ.
  BB. Two ocelli present; insects aerial, although living near the water; body short and broad; eyes very prominent. Fam. XVI.—GALGULIDÆ.
AA. Antennæ prominent, free, rarely (Phymatidæ) fitting in a groove under the lateral margin of the pronotum.
  B. Body linear; head as long as the three thoracic segments. Fam. XX.—LIMNOBATIDÆ.
  BB. Body of various forms, but, when linear, with head shorter than the thorax.
    C. Distal segment of the tarsi more or less bifid, with the claws inserted before the apex.
      D. Body usually elongated, prothorax narrow; rostrum 4-jointed; second and third pairs of legs extremely long and slender. Fam. XIX.—HYDROBATIDÆ.
      DD. Body usually stout, oval, and broadest across the prothorax; rostrum 3-jointed; legs not extremely long. Fam. XVIII.—VELIADÆ.
    CC. Distal segment of the tarsi entire; claws inserted at the end.
      D. Antennæ 4-jointed.*
        E. Wing-covers reticulated, and of one uniform thin substance throughout; very rarely (Piesma) with a distinction between the corium and membrane. Fam. XXVI.—TINGITIDÆ.
        EE. Wing-covers of various forms or absent, but not of the form presented by the Tingitidæ. See Fig. 171.
          F. Rostrum 3-jointed.
            G. Ocelli wanting.
              H. Wing-covers rudimentary, with only corium (Acanthiinæ). Fam. XXVII.—ACANTHIIDÆ.

* In certain families there are minute intermediate joints between the principal joints of the antennæ. For the purposes of this table these intermediate joints are not counted.

HH. Wing-covers well developed.
I. Body linear. Fam. XXI.—EMESIDÆ.
II. Body not linear.
J. Body greatly flattened. Fam. XXV.—ARADIDÆ.
JJ. Body of ordinary form (Saicinæ).
Fam. XXII.—REDUVIIDÆ.

GG. Two ocelli present, though sometimes difficult to see; wing-covers well developed.
H. Wing-covers with embolium, Fig. 151. (Anthocorinæ.)
Fam. XXVII.—ACANTHIIDÆ.
HH. Wing-covers without embolium.
I. Rostrum long, reaching to or beyond the intermediate coxæ. Fam. XVII.—SALDIDÆ.
II. Rostrum short.
J. Front legs with greatly widened femora.
Fam. XXIV.—PHYMATIDÆ.
JJ. Front femora somewhat thickened, but much less than half as wide as long. Fam. XXII.—REDUVIIDÆ.

FF. Rostrum 4-jointed.
G. Membrane of wing-covers with longitudinal veins; legs either raptorious or ambulatory.
H. Membrane usually with four long veins bounding three discal cells, which are often open. From these cells diverge veins all around and form several marginal cells (Fig. 150); legs raptorious. Fam. XXIII.—NABIDÆ.
HH. Membrane with 4 or 5 simple or anastomosing veins arising from the base; or with a larger number of veins arising from a cross vein at the base; legs ambulatory.
I. Ocelli wanting; membrane with two large cells at the base; and from these arise branching veins (Fig. 153).
Fam. XXIX.—PYRRHOCORIDÆ.
II. Ocelli present.
J. Head with a transverse incision in front of the ocelli.
Fam. XXXI.—BERYTIDÆ.
JJ. Head without transverse incision.
K. Membrane with 4 or 5 simple veins arising from the base of the membrane; the two inner ones sometimes joined to a cell near the base (Fig. 154).
Fam. XXX.—LYGÆIDÆ.
KK. Membrane with many, usually forked, veins, springing from a transverse basal vein (Fig. 155).
Fam. XXXII.—COREIDÆ.
GG. Membrane of wings-covers with one or two closed cells at its base, otherwise without veins (Fig. 152); legs ambulatory.
Fam. XXVIII.—CAPSIDÆ.
GGG. Membrane of wing-covers without any veins; legs ambulatory. Fam. XVIII.—HEBRIDÆ.

DD. Antennæ 5-jointed.*

E. Lateral margin of scutellum with a furrow in which the edge of the wing-cover fits when closed.

F. Scutellum nearly flat, attenuated posteriorly.

G. Tibiæ unarmed or furnished with very fine short spines.

Fam. XXXIII.—PENTATOMIDÆ.

GG. Tibiæ armed with strong spines in rows.

Fam. XXXIV.—CYDNIDÆ.

FF. Scutellum very convex, covering nearly the whole abdomen.

Fam. XXXV.—CORIMELÆNIDÆ.

EE. Lateral margin of the scutellum without a furrow; scutellum very convex, covering nearly the whole abdomen.

Fam. XXXVI.—SCUTELLERIDÆ.

FIG. 150.—*Nabidæ.*

FIG. 151.—*Anthocorinæ.*

FIG. 152.—*Capsidæ.*

FIG. 153.—*Pyrrhocoridæ.*

FIG. 154.—*Lygæidæ.*

FIG. 155.—*Coreidæ.*

Family XI.—CORISIDÆ.†

(*Water-boatmen.*)

To the *Corisidæ* belong certain aquatic *Heteroptera* which are very widely and commonly distributed throughout our country. They are of medium or small size, and of somewhat elongated oval form. They occur in lakes, ponds, and streams, in both stagnant and running water, and even in the salt lakes of Utah and California.

All of the North American species of this family belong to the genus *Cŏrisa*. Fig. 156, which represents a species of *Corisa*, illustrates the form of the body. These insects may be distinguished by the peculiar tarsi of the front legs. These tarsi are flattened or scoop-like in form; each consists of a single segment, and bears a comb-like fringe of bristles. The structure of the head of these insects is quite unusual. Instead of being inserted in the prothorax, the head overlaps that segment. The position of the mouth-parts is also peculiar; these are pushed through an open-

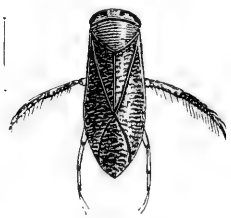

FIG. 156.—*Corisa undulata.*

* In certain families there are minute intermediate joints between the principal joints of the antennæ; for the purposes of this table, these intermediate joints are not counted.

† Corĭsidæ, Corisa: *coris* (κόρις), a bug.

ing in the clypeus instead of being articulated to its tip. In the males of *Corisa* the abdominal segments, especially the four caudal ones, are very unsymmetrical, being upon one side broken into irregular-shaped fragments.

These water-boatmen have the body flattened above, and swim upon their ventral surface; they differ in these respects from the members of the next family. They swim with a quick, darting motion; they use for this purpose chiefly their long, oar-like posterior legs. When in their favorite attitude, they are anchored to some object near the bottom of the pond or aquarium by the tips of their long, slender, intermediate legs, at such times the fore legs hang slightly folded, and the posterior legs are stretched out horizontally at right angles to the length of the body. The body of these insects with the air which clings to it is much lighter than water; consequently, whenever they loose their hold upon the object to which they have been clinging, they rise quickly to the surface, unless they prevent it by swimming. They occasionally float on the surface of the water, and can leap into the air from the water and take flight.

The bodies of these insects, as they swim through the water, are almost completely enveloped in air. The coating of air upon the ventral surface and sides can be easily seen, for it glistens like silver. By watching the insects carefully, when they are bending their bodies, air can be seen to fill the spaces between the head and prothorax, and between the prothorax and mesothorax. The space beneath the wings is also filled with air. When these insects are in impure water, they must come to the surface at intervals to change this supply of air. But I have demonstrated that in good water it is not necessary for them to do this. The air with which the body is clothed is purified by contact with the fine particles of air scattered through the water; so that the insect can breathe its coat of air again and again indefinitely.*

The Water-boatmen are carnivorous, feeding upon other insects. They attach their eggs to aquatic plants; and the young are found in the same situations as the adults.

"In Mexico, the eggs of a species of *corisa* are said to be gathered from water-plants, and used as an article of food by the dwellers near the lakes where they abound. The natives cultivate a sedge upon which the insects will deposit their eggs. This sedge is made

* See account of my experiments in *American Naturalist*, June, 1887.

into bundles, which are then floated in the water of a lake until covered with eggs. The bundles are then taken out, dried, and beaten over a large cloth. The eggs being thus disengaged, are cleaned and pounded into flour." (Glover.)

Family XII.—NOTONECTIDÆ.*

(*Back-swimmers* or *Back-swimming Water-boatmen.*)

The *Notonectidæ* differ from all other aquatic Heteroptera by the fact that they always swim on their back. And there is a corresponding difference in the form of the body. This is much deeper than in the allied families, and is more boat-shaped. The back, from the peculiar attitude of the insect when in the water, corresponds to the bottom of a boat, and is sloped so as to greatly resemble in form this part (Fig. 157).

FIG. 157.—*Notonecta undulata.*

The eyes are large, uniform, twice sinuated on the outer side, and project a little way over the front margin of the prothorax. The prothorax has the lateral margins sharp and projecting. The legs are all long; the hind pair are much the longest and fitted for swimming. The tarsi consist each of three segments, but the basal segment is so small that it is often overlooked. There is a ridge along the middle line of the venter which is clothed with hairs.

These insects are predaceous, feeding upon insects and other small animals. In collecting them, care must be taken or they will inflict painful stings with their sharp and powerful beak.

The favorite attitude of the Back-swimmers is floating at the surface of the water, with the caudal part projecting sufficiently to admit of the air being drawn into the space beneath the wings. When in this position, their long oar-like hind legs are stretched outward and forward ready for action. When disturbed, they dart away toward the bottom of the pond, carrying a supply of air for respiration beneath their wings. As in the Corisidæ, the body of these insects with the air which they carry for respiration is much lighter than water; consequently, the moment they stop swimming, they rise to the surface of the water if they do not cling to some object to prevent it. Occasionally these insects will float on the surface of the water with their dorsal aspect uppermost; and, like the

* Notonĕctidæ, Notonĕcta: *notos* (νῶτος), back; *nectos* (νηκτός), swimming.

Water-boatmen, they can leap into the air from the water and take flight.

There are three genera in North America. The greater number of our common species belong to *Notonecta*. The following table of the genera is from an unpublished work by Professor H. E. Summers:

A. Apices of hemelytra entire; the three pairs of legs similar in shape. PLĒA.
AA. Apices of hemelytra notched; legs dissimilar.
  B. Hemelytra much longer than abdomen; fourth segment of antennæ longer than third. ANISOPS.
  BB. Hemelytra but little longer than abdomen; fourth segment of antennæ shorter than third. NOTONĔCTA.

Family XIII.—NEPIDÆ.*

(*Water-scorpions.*)

The members of this family can be distinguished from other aquatic Heteroptera by the presence of a long respiratory tube at the end of the abdomen. This tube consists of two long filaments, each with a groove on its mesal side. By applying these filaments together the grooves form a tube, which conducts the air to two spiracles situated at the caudal end of the abdomen. By means of this apparatus these insects are able to rest on the bottom of a shallow pond, or among rubbish or plants in water, and by projecting this tube to the surface obtain what air they need.

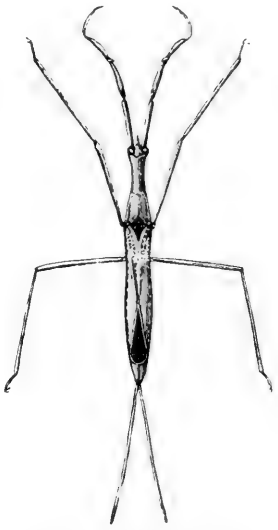

FIG. 158.—*Ranatra fusca.*

With regard to the form of the body two very different types exist in this family. In one, represented by the genus *Nēpa*, the body is a long-oval, flat and thin; in the other, represented by the genus *Rănatra*, the body is almost linear and cylindrical (Fig. 158).

The Water-scorpions are carnivorous; and with them the first pair of legs is fitted for seizing prey. In these legs the coxæ

* **Nĕpidæ**: *Nepa*, a scorpion.

are very long, especially in *Ranatra:* the femora are furnished with a groove into which the tibiæ and tarsi fit like the blade of a pocket-knife into its handle.

Although the Nepidæ are truly aquatic insects, the second and third pairs of legs are fitted for walking rather than swimming.

Of the genus *Nēpa* we have only a single species, *N. apiculāta.* This insect is about two-thirds of an inch in length, not including the respiratory tube, which measures a little more than one-fourth of an inch. It lives beneath stones and rubbish in ponds, and in the quiet parts of our streams.

Of the genus *Rănatra*, our most common species is *R. fŭsca* (Fig. 158). This insect lives in the same situations as *Nepa.* Owing to the linear form of its body, and to the dirt with which it is usually covered, it is quite difficult to detect the presence of this insect among the rubbish where it is found. Doubtless this resemblance to a dirty stick aids it greatly in the capture of insects, fish, and other unwary animals upon which it preys.

Family XIV.—Belostomatidæ.*

(*Giant Water-bugs.*)

"The family *Belostomatidæ* contains the largest Heteroptera now in existence. These are all wide and flat-bodied aquatic insects, of more or less ovate outline, furnished with powerful flattened swimming-legs, the fore tibiæ curved as in the preceding family, and fitted for seizing and holding tightly the victims, upon which they pounce from their hiding places in the rubbish or among the branches of water-plants. A remarkable feature of all the genera is in the presence of a pair of flattened, narrow, strap-like appendages at the end of the body, which are extensile, but not concerned with respiration, as in members of the foregoing group". (Uhler.)

These insects are rapacious creatures, feeding on other insects and small fish. Some of the species are of great size. One found in Guiana and Brazil sometimes measures four inches in length. We have in our fauna two common species of the larger Giant Water-bugs. They are *Belŏstoma americānum* and *Benăcus grĭseus.* These two species so closely resemble each other that they are commonly confounded.

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*Belostomătidæ, Belŏstoma: *belos* (βέλος), a spear; *stoma* (στόμα), a mouth.

Belŏstoma americānum (Fig. 159) varies greatly in size. Specimens before me as I write this range from 44 mm. (1.75 in.) to 60 mm. (2.4 in.) in length. It is of a pale dirty-brown color, mottled with dark brown; the ventral aspect of the body is speckled with dark brown. The anterior femora are furnished with a groove for the reception of the edge of the tibiæ.

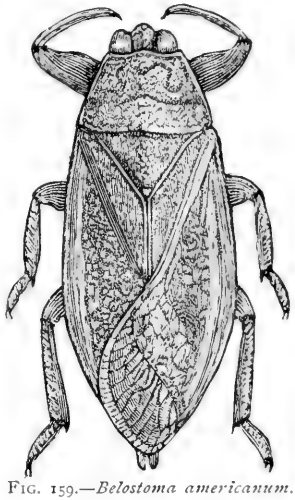

Fig. 159.—*Belostoma americanum.*

Benācus grīseus can be distinguished from *Belostoma* by the absence of the femoral groove. In *Benacus* the ventral aspect of the thorax is marked by five interrupted longitudinal stripes of dark brown.

To the genus *Zāitha* belong our more common representatives of the smaller members of this family. The common species of the Eastern United States is *Zāitha flumĭnea.* This measures about nine-tenths of an inch in length, and bears a round scar on each side of the prothorax (Fig. 160). The females of this species lay their eggs upon their own backs. These eggs are set upon end, and placed in transverse rows, by means of a long protrusile tube or ovipositor, which the insect can extend far over her own back. The eggs are fastened to the back of the mother by a very thin layer of a waterproof gum secreted by the insect. At about the time when the young brood begins to hatch, the mother sheds the entire layer of eggs from her back. (Dimmock.)

Fig. 160.—*Zaitha flumĭnea.*

Family XV.—Naucoridæ.*

The *Naucoridæ* includes flat-bodied, chiefly oval insects, which are of smaller size than the members of the preceding family. The abdomen is without caudal appendages, and the legs are suited for crawling rather than for swimming. The front legs, however, are fitted for grasping, the femora being greatly thickened. There are no

* Naucŏridae, Naucoris: *naus* (ναῦς), a boat; *coris* (κόρις), a bag.

ocelli; the antennæ consist of four simple segments, are very short, and well concealed beneath the eyes. The rostrum is three-jointed, and covered at the base by the large, transverse, triangular or rounded labrum, and the wing-covers are furnished with a distinct embolium.

The members of this family are predaceous; and, according to Uhler, they are fond of reedy and grassy, quiet waters, where they creep about like the Dyticid beetles, creeping and half-swimming around and between the leaves and sprays of the submerged plants, and suddenly seizing any unlucky *Corisa* or other insect that happens to be within reach.

The family is a small one; as yet, less than fifty species have been described. These are distributed among twelve genera. Of those that occur in the United States, only five species, representing two genera, have been described. But one of these is found in the States on the Atlantic coast. This is *Pelŏcoris femorāta*. It measures about 9 mm.(0.35 in.) in length, and after death is pale yellow or brownish in color, with black or dark-brown markings. The remaining species are found in the Western States, and belong to the genus *Ambrȳsus*. This genus differs from *Pelocoris* in having the front margin of the prothorax very deeply sinuate.

Family XVI.—Galgulidæ.*

The *Galgulidæ* is the concluding member of the series of families of Heteroptera characterized by short antennæ, nearly or quite concealed beneath the head. This family differs from the other families of the series in that the species present a pair of ocelli. In the more typical forms, the body is very broad and short, and the eyes are prominent and projecting. Fig. 161 represents the characteristic form of these insects.

Fig. 161.—*Galgulus oculatus.*

The Galgulidæ differ from the other short-horned bugs in habits. Whilst the members of the preceding families are truly aquatic, these insects pass their lives on the muddy margins of streams, or about the other parts of marshes, where the soil is moist but not continuously submerged. Some of them make holes for themselves, and live for a part of the time beneath the ground.

This is a small family, containing only about a score of known

* Galgūlidæ: *gălgulus*, the witwall or yellow thrush.

species. Of these, only three, representing three genera, have been catalogued from the United States. Our forms can be separated by the following table:

A. Fore-legs stout, fitted for grasping.	
B. Anterior tarsi with a single claw.	MONONYX.
BB. Anterior tarsi with two claws.	GALGULUS.
AA. Fore-legs slender, fitted for running.	PELOGONUS.

Our three species are *Mŏnonyx stÿgicus*, *Gălgulus oculātus*, and *Pelŏgonus americānus*. Fig. 161 represents the *Galgulus*: the *Mononyx* closely resembles this in form; while the *Pelogonus* is a smaller insect, with a more oblong body, and of a velvety black color. All of the species are predaceous.

Family XVII.—SALDIDÆ.*

With the *Săldidæ* we reach the beginning of the extensive series of families of Heteroptera, in which the antennæ are prominent and are not concealed beneath the head. In this family the insects are of small size, and of dark colors, with white or yellow markings. The head stands out free from the thorax on a cylindrical base. The antennæ are four-jointed; there are two ocelli; the rostrum is three-jointed and very long, reaching to or beyond the middle coxæ. The membrane of the wing-covers is furnished with looped veins, forming four or five long cells placed side by side. Occasionally there is little or no distinction between the corium and membrane. Two forms sometimes occur in the same species, one with a distinct membrane, and another with the membrane thickened and almost as coriaceous as the corium proper.

FIG. 162.—*Salda.*

In regard to the habits of the Saldidæ, Uhler states as follows: "In the present family we have types which, like *Gălgulus*, make holes for themselves, and live for a part of the time beneath the ground. Like the members of that genus, too, a majority of these inhabit damp soils, and are often found in countless numbers on the salt or brackish marshes of our sea-coasts. Their manners strongly recall those of the Tiger-beetles that inhabit the same places. When approached, or in any way disturbed, they leap from the ground, arise a few feet into the air by means of their wings, and alight a

* Săldidæ: *Salda*, a proper name.

short distance away, taking care also to slip quickly into the shade of some projecting tuft of grass or clod where the soil agrees with the color of their bodies."

About thirty species have been described from the United States and British America. These all belong to the genus *Sălda*.

Family XVIII.—Veliadæ.*

The *Velīadæ* includes insects which are very closely allied to the water-striders both in structure and habits. In both families, the distal segment of the tarsi is more or less bifid, and the claws are inserted before the apex. These characters distinguish these two families from all other Heteroptera. In the Veliadæ the body is usually stout, oval, and broadest across the prothorax, (Fig. 163). The rostrum is three-jointed, and the legs are not extremely long. In fact, the legs are fitted for running over the water, instead of for rowing, as with the Hydrobatidæ.

Fig. 163. — *Rhagovelia collaris.*

The Veliadæ "pass most of their lives upon the surface of the water, but always near the banks of the stream or pond; but they also make excursions beyond the limits of the water, and move with great freedom upon the land." (Uhler.)

Less than a dozen species have been described from the United States; but these represent six genera.

Family XIX.—Hydrobatidæ.†

(*Water-striders.*)

This family includes elongated or oval insects which live upon the surface of water. Several species are very abundant on our ponds and streams. They run over the surface of the water very rapidly; and, like the Whirligig-beetles, often congregate in great numbers. The head is inserted in the thorax up to the base of the eyes; these are round and prominent. The antennæ are long, and consist of four segments. "The thorax usually widens backwards, and its thickness is increased by the prominent middle and posterior coxæ, which project beyond the sides. No scutellum is apparent (except in *Stephania*), but in its place the end of the dorsal plate of

* Velīadæ: *Velia*, a proper name.

† Hydrobătidæ, Hydrobates: *hydor* (ὕδωρ), water; *bates* (βάτης), one that treads.

the mesothorax is scale-like, narrowed, rounded, and depressed around the tip. Behind this, the abdomen tapers more or less towards the last segment, which is usually armed each side with a tooth-like process. The under side of the body is generally minutely pubescent and sericeous like satin, and this is sometimes continued along the sides of the thorax. There are commonly two forms of the adult belonging to the same species, the winged and unwinged. These do not necessarily co-exist. During some years, only the winged forms appear; while in others, and especially if the spring and summer are cool, the individuals will all be unwinged. Often in sunny, protected places, where the food is abundant, all will be winged, while, in exposed localities, the same species will be found unwinged, with, perchance, a single, more vigorous specimen winged. In some parts of the Southern States three forms occur, those before cited and another which has the wing-covers of scarcely half length." (Uhler.)

The water-striders prefer quiet waters, upon which they rest, or over which they skim rapidly. They jump from the water to capture flies or other insects for food. Fig. 164 represents a species of *Hygrŏtrechus.* "These insects stow themselves away under the banks of streams, in the mud beneath leaves or rubbish, or at the bottom of water under stones and roots of trees when the autumn begins to be cold; and from thence they reappear upon the surface of the water as soon as the warm weather of spring returns. Soon after this, the eggs are attached by a sort of glue to the leaves and stems of aquatic plants. They are whitish translucent, long, cylindrical, more blunt at the end from which the young emerge than at the somewhat tapering, but round, opposite extremity. If the weather continues to grow warmer, these eggs mature in about two weeks." (Uhler.)

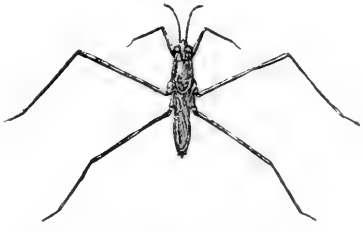

Fig. 164.—*Hygrotrechus conformis.*

Five genera occur in our fauna; these can be separated by the following table: *

A. Body oval, less than three times as long as broad; pronotum not longer than broad.

* This table was prepared by Professor H. E. Summers.

B. Second segment of antennæ longer than either the third or fourth. METRŎBATES.

BB. Second segment of antennæ shorter than either the third or fourth. STEPHĀNIA.

AA. Body elongate, more than four times as long as broad; pronotum much longer than broad.

B. Antennæ longer than head and pronotum together; the posterior tibiæ and tarsi together much longer than the intermediate tibiæ. LIMNŎPORUS.

BB. Antennæ shorter than the head and pronotum together; the posterior tibiæ and tarsi together but little longer than the intermediate tibiæ.

C. First segment of antennæ nearly equal in length to the fourth. LIMNŎTRECHUS.

CC. First segment of the antennæ considerably longer than the fourth. HYGRŎTRECHUS.

Closely allied to *Stephānia*, and resembling it in the form of their bodies, are the species which constitute the genus *Halŏbates*. These are truly pelagic insects, living on the surface of the ocean, often hundreds of miles from land. They are most abundant in the region of calms near the equator; they feed on the juices of dead animals floating on the surface, and probably attach their eggs to floating sea-weed (*Sargassum*).

Family XX.—LIMNOBATIDÆ.*

The members of this family are very long, slender insects, with linear legs and antennæ. The head is nearly cylindrical, and longer than the thorax; the eyes are round, projecting, and placed a little nearer the base than the tip of the head. These insects creep slowly upon the surface of the water; they carry the body considerably elevated; and are found mostly where plants are growing in quiet waters. "They delight to remain at rest, with perhaps a single claw hooked to some projecting object. When disturbed, they move very slowly, and seem disposed to save themselves rather by concealment among rubbish or tangled growths than by active movements. The young forms are so very slender that they can only be detected with great difficulty in the places to which they resort." (Uhler.)

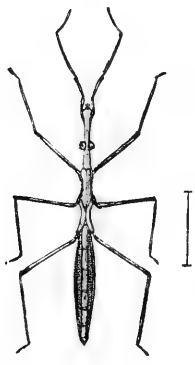

FIG. 165.—*Limnobates lineata.*

* Limnobătidæ, Limnobates: *limne* (λίμνη), a salt marsh; *bates* (βάτης), one that treads.

I find no observations regarding the food of these insects; but they are probably herbivorous.

Only a single species has been found in the United States. This is *Limnŏbates lineāta.* It is a small insect less than 12.5 mm. (0.5 in.) in length. The legs and antennæ are extremely slender, being hair-like in form. Fig. 165 represents this species greatly enlarged.

Family XXI.—Emesidæ.*

The *Emĕsidæ* includes a small number of insects in which the body is very slender, and the middle and hind legs are thread-like. The front legs are less thread-like, and fitted for grasping. They suggest by their form the front legs of the Mantidæ; the coxa is very greatly elongated, more than four times as long as thick; the femur spined; and the tibia shut back upon the femur.

This family is very closely allied to the one following. In fact, by some authors the two are united. They agree in having the rostrum short, attached to the tip of the head, and with the distal end when not in use resting upon the prosternum, which is grooved to receive it. The great length of the fore coxa easily distinguishes this family from any of our species of the Reduviidæ, and in the Emesidæ there are no ocelli. Only seven species of this family are catalogued from the United States.

Our most familiar representative is *Ĕmesa lŏngipes.* This insect, by its elongated form and slender legs, at first sight reminds one of the walking-sticks. But the raptorial fore legs, the wings, and the rostrum, really give this species a very different appearance from those insects. Its body measures about 33 mm. (1.3 in.) in length; the middle and hind legs are each about 40 mm. (1.6 in.) long; while the narrow wings are only one-fourth as long as the legs. As indicated by the structure of the fore legs, these insects are predaceous.

Four genera are represented in our fauna; these can be separated as follows:†

A. The pre-tibiæ and pre-tarsi together not shorter than the pre-femora.
  B. Eyes large, very prominent; when seen from the side, occupying the whole side of the head. 1. Luteva.
  BB. Eyes small, slightly prominent; when seen from the side, not occupying more than half of the side of the head. 2. Cerascopus.

* Emĕsidæ: *Emesa*, a proper name.

† Table prepared by Professor H. E. Summers.

AA. Pre-tibia and pre-tarsi together shorter than the pre-femora.
B. Pre-tarsi one-clawed. 3. BARCE.
BB. Pre-tarsi two-clawed. 4. EMESA.

Family XXII.—REDUVIIDÆ.*

The *Reduvīidæ* is a large family, including numerous genera of diverse forms. Many of the members of it are insects of considerable size; and some are gayly colored. They are predaceous, living on the blood of insects. In some cases, they attack the higher animals; and, occasionally, even man suffers from them. As already stated, this family is closely allied to the preceding. But the species differ from the Emesidæ in having the body and legs thicker. The front coxæ are shorter, being never more than two or three times as long as broad; and, in the case of the species found in the United States, two ocelli are present. These insects agree with the Emesidæ in having the rostrum short, three-jointed, attached to the tip of the head, and with the distal end, when not in use, resting upon the prosternum, which is grooved to receive it.

In Uhler's Catalogue of the Hemiptera of North America (1886), fifty genera of the Reduviidæ representing nine sub-families, are enumerated. Only a few of the more familiar species can be referred to in this place.

The Masked Bed-bug-hunter, *Opsicœtus personātus*.—The member of this family about which probably most has been written is the one for which I propose the popular name given above. The species is a European one, and is described in nearly all of the European text-books of entomology under the name *Redūvius personātus*. But it is now placed in the genus *Opsicœtus*. A variety of this species occurs in the Atlantic region of our country. Fig. 166 represents the adult insect. It measures from 15–20 mm. (0.6–0.8 inch) in length. It is black, or of a very dark brown. The prothorax is strongly constricted in the middle, rounded in front, and has a prominent groove on the middle line.

FIG. 166.—*Opsicoetus personatus.*

There are two marked peculiarities of this species which has caused it to attract much attention: first, in its immature stages, the body is covered with a viscid substance which causes particles of dust and fibres to adhere to it; not only the body proper, but the legs and

* Reduvīidæ, Redūvius: *reduvia*, a hang-nail.

antennæ also are masked in this way: second, this species infests houses for the sake of preying upon the bed-bug. It feeds also upon flies and other insects. Dr. Le Conte, in writing of this insect, states that it is remarkable for the intense pain caused by its bite; that, when caught or unskilfully handled, it always stings. In this case, the pain is almost equal to that of the bite of a snake, and the swelling and irritation which result from it will sometimes last for a week. In very weak and irritable constitutions it may even prove fatal.

The Big Bed-bug, *Conŏrhinus sanguisūgus.*—Closely allied to the masked bed-bug-hunter is a large bug which insinuates itself into beds for a less commendable purpose than that of its ally; for it sucks human blood at first hand.

This insect measures 25 mm. (1 inch) in length. It is black, marked with red. The prothorax is triangular, with a tubercle in front on each side, slightly constricted before the middle, in front with two raised lines diverging backwards, and most raised in front, margined with red; scutellum with two raised diverging lines directed forwards and joined at the base; wing-covers with two triangular red spots on each, one at the base, the other near the middle on the outside; abdomen with six red spots on each side, both above and below. The species was first described from Georgia; but it occurs also in the more Northern and Western States. It, too, is remarkable for sucking the blood of mammals, particularly children. Dr. Le Conte, who first described this insect, says that it, like the preceding species, inflicts a most painful wound. And that he has known its bite to be followed by very serious consequences, the patient not recovering from its effects for nearly a year. He states his belief also that the accounts which we have of persons being bitten by spiders are based on stings of these or allied insects.

Although the species referred to above will serve to illustrate the form of the members of this family, they are exceptional in habits. I know of no others that habitually enter the dwellings of man. Usually the members of this family pass their lives upon trees, shrubs, or herbage, adroitly catching their prey. They feed upon various insects both in the larva and adult states. Numerous instances are on record of their destroying the Colorado potato-beetle, the Rocky Mountain locust, and other important pests.

The wheel-bug, *Prĭonidus cristātus* (Fig. 167) furnishes a good illustration of the habits of the predaceous members of this family. This is a common insect in the South. The adult, a cluster of eggs, and several nymphs are represented in the figure. The hexagonal

masses of eggs are deposited on the bark of trees, on fence-rails, under the eaves of out-buildings, or wherever the female chances to be

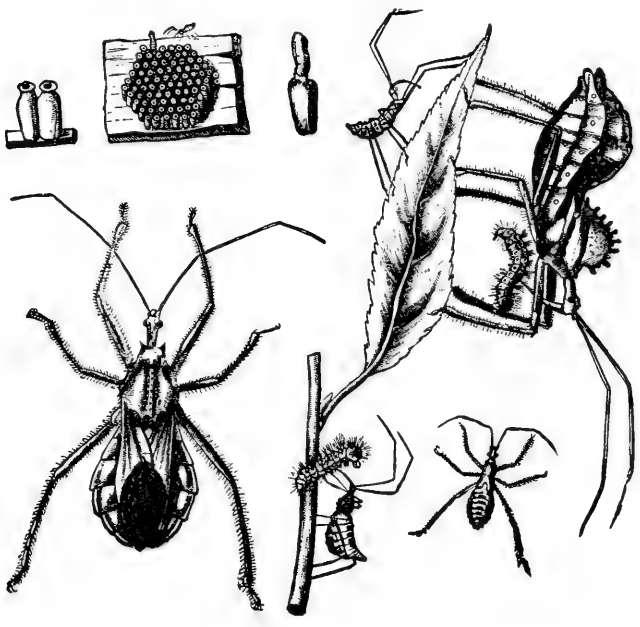

FIG. 167.—*Prionidus cristatus.* (From Glover.)

at the time of oviposition, to the number of 70 or more. The nymphs when young are blood-red, with black marks, and do not resemble the adult insect excepting somewhat in form and in habits. Both the nymphs and adults feed upon all other insects they can overcome, not even sparing their own kind. "They kill their prey by inserting into it the proboscis, which ejects a most powerful poisonous liquid into the wound. The victim thus pierced dies in a very short time. They then leisurely suck the juices out, and drop the empty skin. The perfect insect is of a gray color, and has a high semicircular ridge or projection on the crest of its thorax." (Glover.)

Family XXIII.—NABIDÆ.*

We have but few representatives of the *Nabidæ;* but some of them are very common. In this family the body is oblong, and

* Năbidæ: *Nabis,* a proper name.

somewhat oval behind. The rostrum is long, slender, and four-jointed. The wing-covers are longer than the abdomen, or are very short. In the long-winged forms the membrane is usually furnished with four long veins bounding three discal cells, which are often open. From these cells diverge veins all around and form several marginal cells. (Fig. 168.)

Only three genera occur in our fauna; these can be separated by the following table :*

A. Pre-acetabula remote from each other. Clavus and corium semi-transparent. (Sub-family Coriscinæ.) 1. CORĬSCUS.

AA. Pre-acetabula close together. Clavus and corium opaque. (Sub-family Nabinæ.)

B. Joint 2 of rostrum longer than joint 3; joint 2 reaching base of head. 2. PĂGASA.

BB. Joint 2 of rostrum shorter than joint 3; joint 2 not reaching base of head. 3. NĀBIS.

Corĭscus fĕrus is one of our most common species. This insect measures about 8 mm. (0.3 in.) in length. It is pale yellow with numerous minute brown dots. The veins of the membrane are also brownish. This species is widely distributed both in this country and in Europe. It secretes itself in the flowers or among the foliage of various herbaceous plants, and captures small insects upon which it feeds. Fig. 168 represents the wing-cover of this species.

FIG. 168.—Wing-cover of *Coriscus ferus*.

Corĭscus subcoleoptrātus is another very common species, and one that is quite likely to attract attention. Although I have collected very many specimens of it, I have met with only the short-winged form. This is of a shining, jet-black color, with the edge of the abdomen and the legs yellowish. The specimens before me have short wing-covers which barely extend to the second abdominal segment. Uhler says that the long-winged form is much narrower behind, and the wing-covers and abdomen are rather dusky, or piceous, than black.

Family XXIV.—PHYMATIDÆ.†

The *Phymatidæ* is even more poorly represented in this country than the preceding family; but, as in that case, some of the species

* Prepared by Professor H. E. Summers.

† Phymătidæ, Phymata: *phyma* (φῦμα), a tumor.

are very common. Here we find the body extended laterally into angular or rounded projections, suggesting the name of the typical genus. But the most striking character which distinguishes this group is the remarkable form of the front legs. These are fitted for seizing prey. The coxa is somewhat elongated; the femur is greatly thickened, so that it is half or two thirds as broad as long; the tibia is sickle-shaped, and fits closely upon the broadened and curved end of the femur; both tibia and femur are armed with a series of close-set teeth, so that the unlucky insect that is grasped by this organ is firmly held between two saws; the apparently useless tarsus is bent back into a groove in the tibia. Another striking character is presented by the antennæ: the terminal segment is more or less enlarged into a knob. Under the lateral margin of the pronotum there is on each side a groove into which the antenna fits.

Only two genera are represented in our fauna. These can be distinguished as follows:

A. Scutellum short; head with a bifid prolongation above the insertion of the antennæ. PHYMATA.

AA. Scutellum very long, extending to the tip of the abdomen; head without bifid prolongation of the antennæ. MACROCEPHALUS.

Our most common species is *Phymata Wolffii* (Fig. 169). It is a yellow insect, greenish when fresh, marked by a broad black band across the expanded part of the abdomen. It conceals itself in the flowers of various plants, and captures the insects which come to sip nectar. It is remarkable what large insects it can overcome and destroy. Cabbage-butterflies, honey-bees, and large wasps are overpowered by it.

FIG. 169.—*Phymata Wolffii.*

Family XXV.—ARADIDÆ.*

The *Aradidæ* are very easily recognized by the depressed form of the body. In fact they are the flattest of all Heteroptera. They live in the cracks or beneath the bark of decaying trees; and the form of the body is especially adapted for gliding about in these cramped situations. They are usually of a dull brown color; sometimes they are varied with reddish or pale markings. Unlike the preceding family, the legs are all of similar form. There are no ocelli; the antennæ are four-jointed; the rostrum three-jointed; the wing-covers are usually well developed, with distinct corium, clavus,

* Aradidæ, Aradus: *aradus* (ἄρᾰδος), a violent disturbance of the stomach.

and membrane; and the tarsi are two-jointed. The species are said to feed upon fungi. It is desirable that observation should be made upon their habits. The family is not a large one. Only a little more than a score of species are now catalogued from the United States. They are of medium or small size; our largest one measures less than half an inch in length. Fig. 170, *Ăradus acūtus*, will serve to represent the form characteristic of the family.

FIG. 170.—*Aradus acutus.*

Our genera can be separated by the following table:*

A. Rostrum reaching only about to base of head; ventral surface of thorax and abdomen not furnished with a fine mesal furrow. (Sub-family BRACHYRHYNCHINÆ).

B. Joint 4 of antennæ much longer than joint 3; scutellum transverse, broad caudad, caudal angle obtusely rounded. 1. ANEURUS.

B. Joint 4 of antennæ not longer than joint 3; scutellum scarcely transverse, triangular, caudal angle acute. 2. BRACHYRHŸNCHUS.

AA. Rostrum reaching about to caudal margin of prosternum or beyond it; ventral surface of abdomen and thorax furnished with a fine mesal furrow. (Sub-family Aradinæ.) ĂRADUS.

Family XXVI.—TINGITIDÆ.†

The *Tingitidæ* are doubtless the most easily recognized of all Heteroptera. The reticulated and gauze-like structure of the wing-covers, usually accompanied by expansions of the prothorax of a similar form, gives these insects a characteristic appearance which needs only to be once seen to be recognized in the future. Fig. 171 represents one of these insects greatly enlarged, the hair-line at the side indicating the natural size of the insect. They are generally very small insects. But they occur in great numbers on the leaves of trees and shrubs.

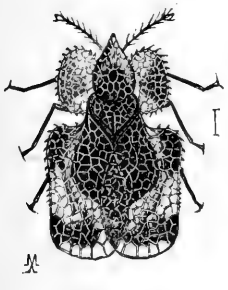

FIG. 171.—*Corythuca arcuata.* (From the Author's Report for 1879.)

In this family the ocelli are wanting; the rostrum and the antennæ are both four-jointed; the scutellum is wanting or rudimentary, replaced by the angular hind portion of the pronotum; and the tarsi are two-jointed.

The family is one of considerable size. There are about forty

* This table was prepared by Professor H. E. Summers.

† Tingītidæ; *Tingis*, a proper name.

known genera, including hundreds of species. Less than a score of species are now catalogued from the United States; but doubtless many more will be found.

There are two well-marked sub-families.

Sub-family I.—TINGITINÆ.

This division includes nearly all of the known species. Here the scutellum is usually covered by an angular projection of the pronotum; and the wing-covers have no distinction between the clavus, corium, and membrane.

The genera that occur in the United States can be separated by the following table:*

A. Discoidal and costal areas of hemelytra rarely jointly elevated; when so elevated, the lateral margins of pronotum never broadly foliaceous, nor with the narrow foliaceous parts (when they are present) produced cephalad.
  B. Rostral sulcus of the sternum not interrupted by a transverse ridge (between the mesosternum and metasternum).
    C. Costal area of hemelytra furnished with a regular single or double series of areoles.
      D. Costal area with a single series of areoles. 1. TELEONĒMIA.
      DD. Costal area with a double series of areoles. 2. TĬNGIS.
    CC. Costal area of hemelytra, at least in part, furnished with a triple or multiple, sometimes confused, series of areoles.
      D. Joint 1 of antennæ not twice as long as joint 2.
        E. Pronotum with a single longitudinal mesal ridge (carina); third joint of antennæ not at all slender. 3. LEPTŌYPHA.
        EE. Prosternum with three parallel longitudinal ridges (carinæ); third joint of antennæ slender. 4. PHYSATOCHĪLA.
      DD. Joint 1 of antennæ at least twice as long as joint 2.
        E. Oblong, anal margins of hemelytra somewhat concave. 5. LEPTOSTŸLA.
        EE. Oval, anal margins of hemelytra convex. 8. ACALYPTA.
  BB. Rostral sulcus of the sternum interrupted between the mesosternum and metasternum by a transverse ridge. 6. GARGĀPHIA.
AA. Discoidal and costal areas of hemelytra jointly elevated; lateral margins of pronotum broadly foliaceous, produced cephalad. 7. CORYTHŪCA.

The following species will serve as an illustration of this subfamily.

The Hawthorn Tingis, *Corythūca arcuāta*.—This I found very abundant in Washington, puncturing the under surface of the leaves

* Prepared by Professor H. E. Summers.

of different species of *Cratægus*. The infested leaves have a brown and sunburnt appearance. All stages were found together. The adult is represented much enlarged by Fig. 171. In Fig. 172 the eggs and immature form are shown. The eggs are smooth, whitish, glistening, semitransparent, and ovoid in shape. Their average length is 3 mm. (0.12 in.). They are deposited on their broad end, and seem to be somewhat inserted into the substance of the leaf; they are covered completely by a brown, sticky substance, which hardens soon after oviposition. It adheres so firmly to the egg, especially to the upper portion, that it is impossible to remove it without crushing the egg. At its upper end this covering of the egg is squarely truncate, giving the whole mass the appearance of a frustum of a cone with a porous lid. From the funnel-shaped summit the young insect makes its exit. The eggs are usually laid, in groups of from ten to thirty, along both sides of some prominent leaf vein. They bear a much greater resemblance to certain forms of fungi, notably the genus *Phoma*, and to certain young Homopterous galls, than they do to eggs of any sort.

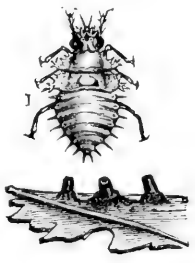

FIG. 172. — Eggs and nymph of *Corythuca arcuata*. (From the Author's Report for 1879.)

The immature insect is of the same dirty brown color as the substance covering the egg, and but little darker than the withering leaf. It is of a broad, flat, oval shape, and spines seem to project from almost every portion of its body. It looks under the microscope more like a lobe of prickly cactus than anything else I can think of. The cast-off skins stick to the leaf, and give it the appearance of being much more seriously infested than it really is.

The dead leaves under the bushes during the winter have been often found to contain the living and healthy eggs of the Tingis; but the customary method of hibernation is in the adult state alone. This form can be found during the winter under the loose bark of the tree, and under sticks and stones on the ground. These insects can be destroyed by strong alkaline washes or by kerosene emulsions. But it is probable that if the leaves and rubbish underneath the trees are destroyed, either every fall or every spring, a necessity for remedies will not arise.

Sub-Family II.—PIESMINÆ.

This division includes a single aberrant genus, *Piĕsma*, of which but few species are known. Here the scutellum is not covered; the

wing-covers have a distinct clavus, with a well-marked claval suture; the clavus is furnished with one, and the corium with three longitudinal veins which are much stronger than the network of veins between them. In long-winged specimens the tip of the membrane lacks the network of veins and appears like the membrane in other families. As yet but a single American species has been described.

The Ash-gray Leaf-bug, *Pĭcsma cinĕrea.*—This measures about 3 mm. (0.12 in.) in length, and is of an ash-gray color. The prothorax is deeply pitted, so that it presents the same appearance as the base of the wing-covers. The head is deeply bifid at tip, and there is a short robust spine between the eye and antenna of each side. This species sometimes infests vineyards to an injurious extent, destroying the flower-buds in early spring.

Family XXVII.—ACANTHIIDÆ.*

The Acanthiidæ comprises two closely allied groups, which have been considered as distinct families, but are now ranked as sub-families. These are the *Acanthiīnæ* and the *Anthocorīnæ*. As these have been separated in the table of families, I will at once proceed to the discussion of them.

Sub-Family. I.—ACANTHIINÆ.

(*Bed-bugs.*)

The *Acanthiīnæ* is represented in this country by a single species, the Bed-bug, *Acănthia lectulāria.* This species is a well-known pest over the greater part of the world. It is reddish-brown in color, and measures in length when full grown from 4 to 5 mm. (0.16 to .018 in.). It presents the following characters, which are those of the sub-family Acanthiinæ: The body is ovate in outline and is very flat (Fig. 173). It is wingless or with very short and rudimentary wing-covers. The labrum is triangular. There are no ocelli. The rostrum consists of three segments; the antennæ, of four; and the tarsi, of three.

FIG. 173.—*Acanthia lectularia.*

The bed-bug is a nocturnal insect, hiding by day in the cracks of furniture and beneath various objects. Ordinarily it is found only in the dwellings of man. But it has been known to infest chicken-coops and pigeon-

* Acanthĭidæ, Acănthia : *acăntha* (ἄκανθα), a thorn.

houses. And the opinion is held that it also infests bats and may be brought into our dwellings by these creatures. I have, however, found no well-authenticated instance of its occurring upon these animals, or of its being found in saw-dust, or under the bark of trees, as has been reported. The means commonly employed to destroy this pest is to wet the cracks of the bedstead and other places in which it hides with corrosive sublimate dissolved in alcohol. This is sold by druggists under the name of bed-bug poison. As this substance is a virulent poison, it should be used with great care. A safer substance to use is Pyrethrum. In case of a badly infested room, it should be thoroughly cleaned; fumed with sulphur; the walls re-papered, kalsomined, or whitewashed; and the wood-work re-painted. In travelling where one is forced to lodge at places infested by this insect or by fleas, protection from them can be had by sprinkling a small quantity of Pyrethrum powder between the sheets of the bed on retiring.

Sub-Family II.—Anthocorinæ.*

(*The Flower-bugs.*)

In the *Anthocorīnæ* the wing-covers are almost always fully developed; and are furnished with an embolium (Fig. 174). The ocelli are present, though sometimes difficult to see. As in the preceding sub-family, the rostrum consists of three segments; the antennæ, of four; and the tarsi, of three.

Fig. 174.—Wing-cover of *Triphleps.*

The species are small. They are found in a great variety of situations, often upon trees and on flowers, sometimes under bark or rubbish. They are predaceous.

Nearly thirty species have been catalogued from the United States. The best known of these is the Insidious Flower-bug, *Trīphleps insidiōsus.* This is often found preying upon the leaf-inhabiting form of the Grape Phylloxera; it is also often found in company with the Chinch-bug, upon which it preys, and for which it is sometimes mistaken.

Family XXVIII.—Capsidæ.†

This is one of the large families of the Heteroptera. Nearly a hundred genera are catalogued from North America alone. The species

* Anthocorīnæ, Anthocoris: *anthos* (ἄνθος), a flower; *coris* (κόρις), a bug.

† Căpsidæ, Capsus: *capsus*, a wagon-body, an enclosure.

are usually of medium or small size; there is a great variation in the form of the body, which makes it difficult to characterize the family. The most available character for distinguishing these insects is the structure of the wing-covers. These are almost always complete, and composed of clavus, corium, cuneus, and membrane. At the base of the membrane there are one or two cells; otherwise the membrane is without veins. See Fig. 175. Other characters of the family are as follows: The ocelli are wanting; the rostrum and antennæ are each four-jointed; the coxæ are subelongate; and the tarsi are three-jointed.

FIG. 175.—Wing-cover of *Pœcilocapsus.*

It is impracticable to discuss here the divisions of this family; I can only refer to a few of the more common species.

The Four-lined Leaf-bug, *Pœcilocăpsus lineātus.*—This is a bright yellow bug, marked with black. It measures about 8 mm. (0.31 in.) in length. There are four longitudinal black lines which extend over the prothorax and the greater part of the wing-covers (Fig. 176). There is in many specimens a black dot on the cuneus of each wing-cover; and the membrane is also black. This insect infests various plants, but abounds most on the leaves of currant-bushes and of sage. It punctures the young and tender leaves, causing small brown spots; but these are sometimes so numerous and closely placed that the leaves become completely withered. This insect is sometimes very abundant during the spring and early summer; and occasionally does great injury. No efficient means of destroying it has been devised except to collect it by jarring the bushes early in the morning while it is torpid.

FIG. 176.—*Pœcilocapsus lineatus.*

The Tarnished Plant-bug, *Lȳgus pratĕnsis.*—The Tarnished Plant-bug is a very common member of the Capsidæ. It is smaller than the preceding species, measuring 5 mm. (0.2 in.) in length, and 2½ mm. (0.1 in.) in its greatest width. It is exceedingly variable in color and markings. It ranges from a dull bark brown to a greenish or dirty yellowish brown. In the more typical forms the prothorax has a yellowish margin and several longitudinal yellowish lines; there is a V-shaped yellowish mark on the scutellum; the distal end of the corium is dark; and the cuneus is pale, with a black point at the apex. This species has been reported as injuriously infesting the young leaves of the expanding buds of pear, and also the unopened buds. Sometimes a whole branch will be thus affected, and will die as the

result of the injury. This species passes the winter in the adult state. When it becomes injurious, the insects should be shaken from the trees upon a sheet, early in the morning, while they are torpid, and destroyed.

The most abundant species of the Capsidæ in the Northeastern United States is one for which I know no popular name, *Leptoptĕrna dolobrāta*. In sweeping the grass of meadows, in early summer, in this locality, frequently more specimens of this bug are taken than of all other insects. This species is very different in form from the two preceding, the body being long and narrow. Fully developed specimens measure 9 mm. (0.4 in.) to the tip of the wing-covers; and are but little more than 2 mm. (.08 in.) in width. The color is greenish yellow marked with black. The markings of the head vary greatly; there are two longitudinal black stripes extending from the eyes over the prothorax and scutellum. The central part and apex of the scutellum is light-colored. There is a variety in which the corneous part of the wing-covers is rust-red.

Family XXIX.—PYRRHOCORIDÆ.*

The members of this family are very different in appearance from those of the preceding family. They are larger, stouter, and more heavily built, and are generally marked with strongly contrasting colors; red with black or brown are the most usual combinations. In coloring these insects resemble some of the larger species of the following family. The Pyrrhocoridæ can be distinguished from the Lygæidæ by the absence of ocelli, and by the peculiar venation of the membrane of the wing-covers (Fig. 177). At the base of the membrane there are two large cells; and from these arise branching veins. Only twenty-five species of this family are catalogued by Uhler from North America; and of these but seven are credited to the United States. Our forms occur in the Southern and Western States.

FIG. 177.—Wing-cover of *Dysdercus.*

FIG. 178.—*Dysdercus suturellus.*

Our most important species, from an economic standpoint, is the Red-bug or Cotton-stainer, *Dysdĕrcus suturĕllus*. This species serves well as an illustration of the appearance of the members of this family (Fig. 178). "It is oblong-oval in form, of a red color; the wing-cov-

*Pyrrhocŏridæ, Pyrrhŏcoris: *pyrrhos* (πυρρός), reddish; *coris* (κόρις), bug.

ers and an arc on the base of the prothorax, and also the scutellum, are pale brown. The wing-covers have the costal margin, a narrow line bordering the base of the membrane and continuing diagonally along the outer margin of the clavus, and also a slender streak on the inner margin of the clavus, pale yellow. It varies much in size, ranging from 10 mm. to 16 mm. (0.4 in. to 0.63 in.) in length." From time immemorial this has been one of the worst pests with which the cotton-planters of Florida and the West Indies have had to contend; it would be difficult to estimate the immense loss it has occasioned. It does much damage by piercing the stems and bolls with its beak and sucking the sap, but the principal injury to the crop is from staining the cotton in the opening boll by its excrement. I found also in Florida that this insect is sometimes very injurious to oranges; it punctures the rind of the fruit with its rostrum; and soon decay sets in, and the fruit drops. The principal injury seems to have been done where cotton was planted in close proximity to the orange-groves. On one occasion I received the eggs of this insect from Florida; they were laid in a group of twenty-one upon the under side of an orange-leaf. They were amber colored, and oval in shape; they appeared smooth and glistening to the naked eye, but an examination with a lens showed them to be densely covered with hexagonal impressions. The young bugs are bright red with black legs and antennæ. These insects can be trapped in cotton-fields by laying chips of sugar-cane upon the earth near the plants; in orange-groves small heaps of cotton-seed will be found useful, as well as pieces of sugar-cane. The insects which collect upon these traps can be destroyed with hot water.

Family XXX.—Lygæidæ.*

The Lygæidæ is another one of the large families of the Heteroptera. It includes certain forms which closely resemble members of the preceding family in size, form, and strongly contrasting colors. But the great majority of the species are of smaller size and less brightly colored; and all differ from that family in presenting distinct ocelli. The membrane of the wing-covers is furnished with four or five simple veins, which arise from the base of the membrane; sometimes the two inner veins are joined to a cell near the

*Lygæidæ, Lygæus: *lygæos* (λυγαῖος), dark.

base (Fig. 179). The antenna of each side is inserted below an ideal line extending from the eye to the base of the rostrum. And the vertex is not constricted in front of the ocelli.

FIG. 179.—Wing-cover of *Lygæus*.

There is a great variety of forms in this family; the North American species are distributed among nearly fifty genera, representing nine sub-families.

The first sub-family, *Lygæinæ*, includes the forms, referred to above, that resemble the Pyrrhocoridæ in coloring. These are chiefly red insects, banded with black across the wing-covers. Among our most common species are the three following:

Oncopĕltus fasciātus.—This is a large red and black insect, measuring 16 mm. (0.63 in.) in length. It has the following-named parts black: legs, antennæ, rostrum, sides, and middle line of the head, disk of the prothorax, scutellum, most of the ventral aspect of the thorax, dots along the lateral edge of the abdomen, the tip of the abdomen, and two spots on each side of the ventral aspect of the same region. There is a broad black transverse band across the middle of the wing-covers; and the membrane is also of the same color. This species "is pretty generally distributed throughout the warm and sheltered parts of this continent, and wherever the larger varieties of Asclepias flourish, either on the coast or inland." (Uhler.)

Lygæus reclivātus.—This is smaller than the preceding species, measuring from 10 to 12 mm. (0.4 in. to 0.47 in.) in length. The head is black, with red spots on the vertex; the thorax is black, with a transverse red band on the disk of the pronotum; this band is sometimes twice interrupted, so that it is represented by three dots; the abdomen is bright red, with the apex, a row of small dots on the lateral edges, and a row of spots on each side of the venter, black; the wing-covers are black, with a red arc opening outwards on each; the free margin of the membrane, a pair of spots on the disk, and two or more irregular spots on the basal margin of the membrane, are snowy white.

A variety occurs in which the white spots on the disk of the membrane are wanting. This variety is the most common representative of the Lygæinæ which I find in central New York. A few of the New York specimens show the white spot; while in a large series of this species in our collection from Arizona these spots are invariably present.

Lygæus tŭrcicus.—This species is very closely allied to the preceding, if not identical with it. Here the red spot on the vertex is

Y-shaped, and includes the antennal tubercles. The membrane of the wing-covers lacks the discal white spots, and the basal half of the clavus is red.

Among the many smaller representatives of this family the following is the best known:

The Chinch-bug, *Blissus leucŏpterus*.—This well-known pest of grain-fields is a small bug, which when fully grown measures a little less than 4 mm. (0.16 in.) in length. It is blackish in color, with conspicuous snowy-white wing-covers. There is on the costal margin of each wing-cover near the middle of its length a black spot; from each of these spots there extends towards the head a somewhat Y-shaped dusky line. The body is clothed with numerous microscopic hairs. In Fig. 180 this insect is represented natural size and enlarged. The species is dimorphic, there being a short-winged form.

FIG. 180. — *Blissus leucopterus.*

There are two generations of the Chinch-bug each year. The insects winter in the adult state, hiding beneath rubbish of any kind; they even penetrate forests and creep under leaves, and into crevices in bark. In early spring they emerge from their winter quarters and pair; soon after the females begin to lay their eggs; this they do leisurely, the process being carried on for two or three weeks. The eggs are yellowish; about 500 are laid by a single insect; they are deposited in fields of grain, beneath the ground upon the roots, or on the stem near the surface. The eggs hatch in about two weeks after being laid. The newly-hatched bugs are red; they feed at first on the roots of the plants which they infest, sucking the juices; afterwards they attack the stalks. The bugs become full-grown in from forty to fifty days. Before the females of this brood deposit their eggs, they leave their original quarters and migrate in search of a more abundant supply of food. About this time the wheat becomes dry and hard; and the migration appears to be a very general one. Although the insects sometimes go in different directions, as a general rule the masses take one direction, which is towards the nearest field of oats, corn, or some other cereal or grass that is still in a succulent state. At this time many of the bugs have not reached the adult state; and even in the case of the fully-winged individuals the migration is usually on foot. In their new quarters the bugs lay the eggs for the second or fall brood.

Satisfactory means of preventing the ravages of this insect are

yet to be discovered. Something can be done by burning in autumn all rubbish about fields, in fence-corners, and in other places where the bugs have congregated to pass the winter. The marching of the spring brood into new fields has been stopped by means of ditches, as is done with the Army-worm. Some farmers have accomplished the same purpose by making a line of gas-tar on the ground; the bugs will not pass such a line, but it is necessary to replace it frequently. In some cases kerosene emulsion can be used to advantage.

Family XXXI.—Berytidæ.*

The *Berytidæ* consists of a small number of species, which on account of their attenuated forms are very striking in appearance. The body is long and narrow; the legs and antennæ are also long and extremely slender. There is a transverse incision in the vertex in front of the ocelli. The antennæ are four-jointed, elbowed at the base of the second segment, and with the tip of the first segment enlarged. The rostrum is four-jointed; and the membrane of the wing-covers is furnished with a very few veins.

Only two genera are catalogued from the United States, each represented by a single species, *Jălysus spinōsus* and *Nēides mūticus*. These can be separated as follows:

In *Jălysus* (Fig. 181) neither the corium nor the venter is punctate; and the vertex is not furnished with a prominent spinous process extending cephalad. There is, however, a small spine on the scutellum, and one on each side of the thorax in front of the coxa. *J. spinōsus* measures about 8 mm. (0.31 in.) in length.

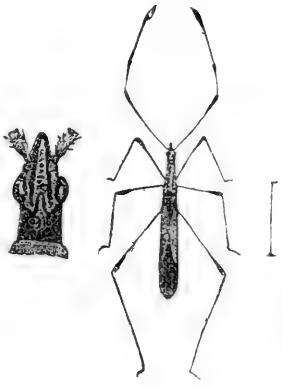

Fig. 181.—*Jalysus spinosus.*

In *Nēides* the corium and venter are strongly punctate; the vertex is furnished with a prominent spinous process extending cephalad. This genus lacks the spines of the scutellum and thorax characteristic of the preceding genus.

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* Berytidæ, Berytus: *βηρυτός*, Greek name of Beyrout.

Family XXXII.—Coreidæ.*

The Coreidæ is one of the most extensive of the families of Heteroptera; and the members of it vary greatly in form. Some of the species are among the most formidable in appearance of all of our Heteroptera; while others are comparatively weak and inconspicuous. The family is characterized as follows: The antennæ are inserted above an ideal line extending from the eye to the base of the rostrum, and are four-jointed; the vertex is not transversely impressed; the ocelli are present; the rostrum is four-jointed; the scutellum is small or of medium size; the wing-covers are usually complete, and composed of clavus, corium, and membrane; the membrane is furnished with many veins, which spring from a transverse basal vein, and are usually forked (Fig. 182); the tarsi are three-jointed.

Fig. 182. — Wing-cover of *Leptocoris.*

This family contains both vegetable feeders and carnivorous forms; in some cases the same species will feed upon both insects and plants.

The most common and best known species is the Squash-bug, *Ănasa trĭstis.* The form of the body of the adult insect is represented in Fig. 183. In this stage the insect appears blackish-brown above and dirty-yellow beneath. The ground color is really ochre-yellow, darkened by numerous minute black punctures. Upon the head are two longitudinal black stripes; the lateral margins of the prothorax are yellow, owing to the absence along a narrow space of the punctures; and the margin of the abdomen is spotted with yellow from a similar cause; the membrane of the wing-covers is black.

Fig. 183. — *Anasa tristis.*

This species winters in the adult state. In early summer it lays its eggs in little patches on the young leaves of squash and allied plants. The young bugs are short and more rounded than the adult insects. There are several generations of this species each year.

This is one of the most annoying of the many pests of the kitchen-garden. The most satisfactory way yet devised for preventing its ravages is to protect the young plants by means of

* Corēidæ, Cōreus: probably from *coris* (κόρις), bug.

boxes or frames covered with netting. After the plants have obtained a good start they are not easily destroyed by this bug.

Metapōdius femorātus (Fig. 184) is a representative of a group which contains the largest members of this family. This species is distributed from North Carolina to Florida and Mexico. It was observed by Prof. Trelease to destroy the Cotton-worm (*Aletia*).

FIG. 184.—*Metapodius femoratus.* (From Glover.)

Family XXXIII.—PENTATOMIDÆ.*

With the *Pentatomidæ* we reach a series of families, four in number, in which the antennæ are five-jointed. I have found no exception to this character within the United States, although there are forms which occur just south of our border in which the antennæ are only three- or four-jointed. This group of insects is very easily recognized; but the student may have at first a little difficulty in separating the families. The body is short, broad, and rather thick The scutellum is always large; we find two types of this part, each characteristic of two families. The first type is presented by the Pentatomidæ and Cydnidæ; here the scutellum is more or less flattened, and triangular in outline, being attenuated posteriorly. In each of these families the lateral borders of the scutellum are furnished with a groove into which the wing-cover fits when not in use.

The form of body presented by the great majority of the members of the Pentatomidæ is well shown by Fig. 185. It is broad, short, and but slightly convex; the head and prothorax form together a triangle. In this family the tibiæ are unarmed, or are furnished with very fine short spines. This is the most available character for separating this from the following family. Of the Pentatomidæ, the genus *Dĭnidor*, which occurs in Mexico, and certain other exotic forms have only four-jointed antennæ.

FIG. 185. — A Pentatomid.

As with the Coreidæ, the members of this family vary greatly in

* Pentatŏmidæ, Pentătoma: *pente* (πέντε), five; *tome* (τομη), section.

their habits; some are injurious to vegetation; others are predaceous; while some species feed indifferently upon animal or vegetable matter.

The Harlequin Cabbage-bug, *Murgăntia histrŏnica.*—Among the species of the Pentatomidæ that feed upon cultivated plants, the Harlequin Cabbage-bug, or "Calico-back" as it is called in some sections, is the most important pest. This is a very common insect in the Southern States. It occurs from New Jersey southward and westward. I have specimens from Colorado, and Arizona. It feeds upon cabbage, radishes, turnips, and other Curciferous plants; it is also found sometimes on plants not closely related to cabbage. The adult bug measures about 10 mm. (0.4 in.) in length. It is polished blue black, banded striped, and margined above with yellow, orange, or red; on the venter it has seven lines of yellow and orange spots; and the head has generally two white spots on the front. The relative proportions of the black and the light colors vary greatly in different specimens. This bug winters in the adult state; in early spring it emerges and lays its eggs on the young plants. The eggs are usually attached to the lower surface of the leaves in two parallel rows of about six each. The young larva is of a uniform pale-green color, marked with black; with the successive moults the various orange markings appear. In the immature stages the antennæ are only four-jointed. This insect develops very rapidly; the eggs hatch on the third day after they are laid; and it is said that the bugs will pass through all of their moults and be ready for reproduction in two weeks. There is a series of generation extending through the entire summer. This is an exceedingly difficult species to contend against. Much can be done by trapping the bugs that have hibernated by placing turnip or cabbage leaves in the garden in early spring.

As if to atone for the destruction caused by their relative, the Harlequin Cabbage-bug, there are many members of this family which aid the agriculturist, by destroying noxious insects. I cannot, without going into details inappropriate here, point out so that they could be recognized the predaceous members of this family. And it would hardly be worth while. It is only in case of exceptional species, like that just described, that these insects occur in sufficient numbers to invite the attention of the agriculturist. They are usually found wandering singly over the plants which they attack or upon which they search for their prey.

The species of the genus *Podisus* have been reported more often

than any other as destroying the Potato-beetle, currant-worms, and other well-known pests. The form of the body of members of this genus resembles quite closely that of the insect represented by Fig. 186. In *P. spinōsus*, the best-known member of the genus, the caudo-lateral angles of the prothorax are prolonged into spines.

FIG. 186.—*Podisus spinosus.* (From Glover.)

Among the smaller members of this family there are two common species which are so well marked that they may be mentioned here.

Cosmŏpepla cărnifex is the more common of the two species. It measures about 7 mm. (0.28 in.) in length; and is of a shining black color, with the body densely punctured. The lateral margin of the body, including the prothorax, basal half of wing-covers, metathorax, and abdomen, is red or orange; the disk of the pronotum is crossed by a transverse and a longitudinal line of the same color; the longitudinal line is widened at its cephalic end so as to cover half of the cephalic margin of this segment. There are also two red or orange spots near the tip of the scutellum.

Mormĭdea lūgens is the other species. This also measures about 7 mm. (0.28 in.) in length. The body is densely punctured; it is olive brown above, and darker beneath. The lateral margin, including the same parts as in the preceding species, is light yellow; the cephalic margin of the prothorax is of the same color; and there is a transverse yellow line on the pronotum a short distance behind its front margin; the scutellum except its cephalic margin is also bordered with yellow.

Family XXXIV.—CYDNIDÆ.*

The characters of this family have been discussed somewhat in the characterization of the preceding one. In the Cydnidæ we find the outline of the body more generally oval, rounded, or elliptical, and the form more convex, than in the Pentatomidæ. The tibiæ are closely armed with strong spines, in rows (Fig. 187), and, with but a single known exception in our fauna, the anterior pair are fitted for digging, being more or less flattened. The scutellum is either broad and bluntly rounded or triangular, with the apex pressed down; the lateral margins are fur-

FIG. 187.—*Cyrtomenus mirabilis.*

* Cydnidæ, Cydnus: *Cydnus*, a proper name.

nished with a furrow into which the margin of the wing-cover fits when not in use. The antennæ are five-jointed except in the exotic genera *Ădrisa* and *Pachymerōides;* the distal three segments are usually united by slender threads.

The species are generally black or very dark brown. They are found burrowing in sandy places, or on the surface of the ground beneath sticks and stones, or at the roots of grass and other herbage. A European species is said to suck the sap from various plants near the ground. It is desirable that further observations be made upon the habits of this family.

Family XXXV.—Corimelænidæ.*

(*The Negro-bugs.*)

This family is represented in our fauna by a single genus, *Corimelæna.* They are mostly black, beetle-like in appearance; some have a bluish or greenish tinge, and all are very convex. The form of the body is similar to that seen in the next family. It is short, broad, and very convex, in fact almost hemispherical. The scutellum is very convex, and covers nearly the whole of the abdomen. At the base of the scutellum there is on each side a short furrow into which the edge of the wing-cover fits when at rest. This character allies this family to the two preceding, and separates it from the following. These insects infest various plants; and often injure raspberries, and other fruit, by imparting a disagreeable, bed-bug-like odor to them. Fig. 188 represents *Corimelæna ātra*, somewhat enlarged; this is a common and widely distributed species.

Fig. 188.—*Corimelæna atra.*

Family XXXVI.—Scutelleridæ.

The Scutelleridæ resemble in the form of their body the preceding family. They are turtle-shaped bugs; that is, the body is short, broad, and very convex. The scutellum is very large, covering nearly the whole of the abdomen. The lateral margin of the scutellum is not furnished with a groove for receiving the edge of the wing cover, as is the case in the three preceding families. The

* Corimelænidæ, Corimelæna: *coris* (κόρις), bug; *melas* (μέλας), black.

† Scutellĕridæ, Scutĕllera: *scutella*, little plate.

antennæ are five-jointed, except in the genus *Augŏcoris*, which occurs in Mexico and in the West Indies, and in certain South American forms; in these they are three-jointed. Fig. 189 represents *Eurygăster alternātus* somewhat enlarged, and serves to illustrate the typical form of members of this family.

FIG. 189.—*Eurygaster alternatus.*

I have met no account of any of our species of this family occurring in sufficient numbers to be of economic importance.

CHAPTER IX.

Order VI.—NEUROPTERA.*

(*Ant-lions, Scorpion-flies, Caddice-flies, et al.*)

The members of this order have four wings; these are membranous, and usually furnished with numerous veins. The mouth-parts are formed for biting except in one family (Phryganeidæ), *where they are rudimentary. The metamorphosis is complete.*

The term Neuroptera, or nerve-winged insects, is applied to the members of this order on account of the numerous veins or nerves with which the wings are strengthened. In this character there is, however, a close resemblance between the Neuroptera and the Pseudoneuroptera. Regarding the relations of these two orders the reader is referred to the remarks on page 62.

It is not certain that the Neuroptera as limited here is a natural group. One family, the Caddice-flies (*Phryganeidæ*), differs so greatly from the other families that it has long been separated as a distinct order; and more recently it has been proposed for similar reasons to treat another family, the Scorpion-flies (*Panorpidæ*), in a like manner. This multiplication of the orders has not yet been generally accepted.

Owing to the great variations in structure exhibited by the different families, it is not easy to make generalizations regarding this order. I will, therefore, reserve the more detailed discussions of the structure of these insects for the special treatment of the individual families.

The Neuroptera includes four families. These can be separated by the following table:

TABLE OF FAMILIES OF NEUROPTERA.†

A. With well-developed wings.
  B. Posterior wings with no anal space; not folded.
    C. Mouth prolonged into a rostrum. 3. PANORPIDÆ.

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* Neurŏptera: *neuron* (νεῦρον), nerve; *pteron* (πτερόν), wing.

† After Baron Osten Sacken in Hagen's Synopsis.

CC. Mouth not prolonged into a rostrum. 2. HEMEROBIADÆ.
BB. Posterior wings with a folded anal space.*
C. Wings reticulate. Prothorax large. 1. SIALIDÆ.
CC. Wings with rather few transverse veins. Prothorax small. 4. PHRYGANEIDÆ.

AA. Wingless, or with rudimentary wings.
B. Mouth prolonged into a rostrum. 3. PANORPIDÆ.
BB. Mouth not prolonged into a rostrum. 4. PHRYGANEIDÆ.

Family I.—SIALIDÆ.†

(*The Dobson et al.*)

There is no common name by which the members of this family as a whole are known. They are, however, easily recognized. Although the typical genus, *Sialis*, includes insects of moderate size, our most common forms are large. All are characterized by having the second pair of wings with a folded anal space, and by having a large prothorax. This segment is either quadrangular or cylindrical and long

The larvæ of all of the forms occurring in the Eastern United States are aquatic, living chiefly under stones in the bed of swiftly-flowing streams. They are carnivorous.

This family is represented in our fauna by four genera. These can be separated by the following table:

FIG. 190.—*Corydalis cornuta*, adult.

A. Wings without pterostigma; prothorax quadrangular.
B. No ocelli. SIALIS.
BB. With three ocelli.
C. Latero-caudal angles of head unarmed. Transverse veins of wings slender. CHAULIODES.
CC. Latero-caudal angles of head with a sharp tooth. Transverse veins of wings stout. CORYDALIS.

AA. Wings with pterostigma; prothorax cylindrical and long. RAPHIDIA.

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* The anal space is absent in a few Phryganeidæ.

† Sĭălidæ, Sĭalis: *sialon* (σίαλον), saliva.

Sīalis.—This genus includes the smaller of our representatives of the family, those having an expanse of wings of about 25 mm. (1 in.). The prothorax is nearly or quite equal in width to the head; there are no ocelli; the antennæ are filiform; the wings are irregularly reticulated with stout veins; and the fourth segment of the tarsi is dilated and bilobed. Our common species is *S. infumāta*. This is black, with the head not narrowed posteriorly; the prothorax is a little wider than the head; and the feet and wings are black. I find the larva of this species common in the swiftly-flowing creeks about Ithaca, adhering to the lower side of stones in the bed of the streams. It resembles in form a young Corydalis, or "Dobson." It has a pair of long tapering appendages on each of the first seven abdominal segments, similar to those of Corydalis. It differs from Corydalis in that the caudal end of the body is terminated by a very long tapering appendage; and there are no tufts of tracheal gills. It is probable that when the larva is full grown it leaves the water and transforms in an earthen cell without a cocoon, as is the case with well-known European species.

Chaulīodes.—The species of Chauliodes are larger than the members of the preceding genus, measuring from 30–60 mm. (1.2 in.–2.4 in.) in length, and having an alar expanse of from 60–100 mm. (2.4 in.–4 in.). They differ also in having ocelli; three in number, and placed close together. This genus closely resembles the following one, but can be distinguished by the characters given in the table above. The two genera also differ in that the caudal appendages of the male are conical and simple in *Chauliodes;* while they are in the form of forceps in *Corydalis.* The larva of *Chauliodes* also greatly resembles that of *Corydalis.* The abdomen is furnished with similar lateral filaments, and anal pro-legs furnished with hooks. But there are no tufts of tracheal gills as in *Corydalis.* The larva of Chauliodes are aquatic, and probably carnivorous.

Chaulīodes pecticŏrnis is a common species with grayish wings and feather-like antennæ. *Chauliodes serricŏrnis* is also common; this is a brownish-black species with the wings spotted with white, and with serrate antennæ.

Corȳdalis.—The characters by which this genus can be recognized have been given in the table above, and in the discussion of the preceding genus. We have but a single common species, the Hellgrammite-fly, *Corȳdalis cornūta.* This is a magnificent insect, having an alar expanse of from 100–135 mm. (4 in.–5.4 in.). The male is remarkable for the great size of its mandibles, which are

more than half as long as the rest of the body. This species is common throughout the greater part of the United States. The larvæ are called "Dobsons" by anglers, and are used by them for bait, especially for bass. Fig. 191 represents a fully grown Dobson, natural size. There is on each abdominal segment a pair of long tapering appendages; those of the ninth abdominal segment are carried back so as to project from the sides of a pair of anal pro-legs. These pro-legs project caudad, and are furnished each with a pair of claws. At the base of each lateral appendage on the first seven abdominal segments there is a tuft of hair-like tracheal gills. The larva also has spiracles; a remarkable instance of an insect provided with both organs for aquatic and aerial respiration. The spiracles are probably not used till the insect is fully grown and leaves the water to undergo its transformations. These larvæ live under stones in the bed of streams. They are most abundant in the swifter parts of the stream. They are carnivorous, feeding upon the larvæ of Stone-flies, May-flies, and other insects. When about two years and eleven months old, the larva leaves the water and makes a cell under a stone or other object on or near the bank of the stream. This occurs at Ithaca during the latter part of May or early in June. By the middle of June the majority of these larvæ have transformed to pupæ. These are of a yellowish-white color. They are furnished with rudimentary wings and legs, and quite long antennæ. During the last half of June the pupæ change to the adult state. The eggs are soon laid. These are attached to stones or to other objects overhanging the water. They are laid in blotch-like masses, which are chalky white in color and measure from 12 to 20 mm. in diameter. A single mass contains from two thousand to three thousand eggs. When the larvæ hatch they at once find their way into the water, where they remain till fully grown.

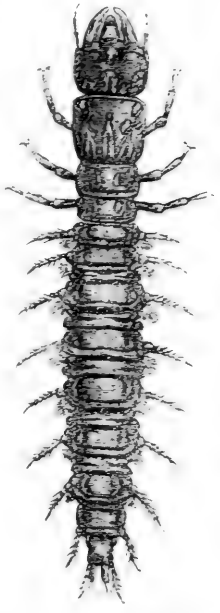


FIG. 191.—*Corydalis cornuta*, larva.

Raphidia.—This genus is represented in this country only on the Pacific Coast. It is distinguished from the other members of the family by having the prothorax cylindrical, and in having the wings

furnished with a pterostigma. The anal space of the second pair of wings is small. The third segment of the tarsi is dilated and bilobed; and the fourth is very short. The abdomen in the female is furnished with a long ovipositor. The larvæ differ from all other Sialidæ in not being aquatic; they are found under bark.

Those species of this genus that have no ocelli have been placed by some writers in a distinct genus, *Inocĕllia*.

Family II.—Hemerobiadæ.*

(*Ant-lions, Lace-winged Flies, et al.*)

The Hemerobiadæ is a family of considerable extent; and representatives of it are very common throughout our country. As a rule they are delicate insects, with large, gauzy wings. These wings are narrow, having no anal space; in this respect they resemble the wings of the Panorpidæ. But the members of this family differ from the Panorpidæ in not having the mouth-parts prolonged into a rostrum. The larvæ of the Hemerobiadæ are predaceous; and they are remarkable for having the mouth-parts formed for sucking. They thus form an apparent exception to the characters of the order Neuroptera. The form of these mouth-parts is a very unusual one. It is well shown in the larva of the Ant-lion, where these organs are large enough to be easily studied. The mandibles are very long; on the ventral aspect of each there is a furrow the entire length; into this furrow the long and slender maxilla fits. In this way the mandible and maxilla of each side form a tube through which the blood of the prey of the insect can be drawn.

Five sub-families are represented in our fauna. These can be separated by the following table:

TABLE OF SUB-FAMILIES OF HEMEROBIADÆ.

A. Prothorax not greatly elongated; the three pairs of legs similar in structure.
  B. Wings with very few veins, and covered with whitish powder.
    1. Coniopteryginæ.
  BB. Wings with numerous veins, and not covered with powder.
    C. Antennæ without terminal enlargement.
      D. Subcostal vein joined to the median before the end of the wing; the principal sector parallel to the median vein and giving rise to the other sectors.† (*Sĭsyra, Polystœchotes.*) 2. Hemerobiinæ.

* Hemerobĭadæ, Hemerōbius: *hemera* (ἡμέρα), day; *bios* (βίος), life.

† For explanation of terms see Fig. 71, p. 73.

DD. Subcostal and median veins separate.
E. Some of the transverse veins between the costal and subcostal forked. (*Micromus, Hemerobius.*) 2. HEMEROBIINÆ.
EE. Transverse veins between the costal and subcostal veins simple. 3. CHRYSOPINÆ.
CC. Antennæ gradually enlarging towards the end, or filiform with a terminal knob. 4. MYRMELEONINÆ.
AA. Prothorax greatly elongated; first pair of legs fitted for grasping. 5. MANTISPINÆ.

Sub-family I.—CONIOPTERYGINÆ.

(*Mealy-winged Neuroptera.*)

This is a sub-family of limited extent; and it includes only small insects. They are characterized by a very small number of veins in the wings, and by having the body and wings covered with a whitish powder. The larvæ are said to have the peculiar form of sucking mouth-parts characteristic of the Hemerobiadæ; and they probably feed upon small plant-lice.

Two genera have been described. *Aleurōnia* has reniform eyes and ciliated wings; in *Coniŏpteryx* the eyes are globose and the wings are not ciliated. Our common species is *Aleurōnia westwoodii*. This occurs in the adult state in June and July; it is black, with the abdomen yellowish; and measures to the tip of the wings 2½ mm. (0.1 inch).

Sub-family II.—HEMEROBIINÆ.

To this sub-family belong many genera, of which several are represented in this country. The antennæ are setiform or moniliform without any terminal enlargement. The wings are furnished with numerous veins, and are not covered with powder. Our genera fall into two groups; the first is represented by *Sĭsyra* and *Polystæchotes*, and the second by *Micrōmus* and *Hemerōbius*. These groups are separated in the table of sub-families given above. The genera in each group can be separated as follows: The costal space* of the front wings of *Sisyra* has no recurrent vein at the base; while in *Polystæchotes* the first transverse vein of this space curves towards the base of the wing, and gives off several branches in its course. The same difference exists between *Micromus* and *Hemerobius*; the former is without the recurrent vein, while it is present in the latter.

* The costal space is the area between the costal and subcostal veins.

The genus *Sisyra* is anomalous in that its larvæ are aquatic. We have a single species described from Georgia. This is a small insect, having an alar expanse of only 9 mm. (0.35 inch).

Polystǣchotes is confined to this continent. These are larger insects, having an alar expanse of from 50 to 75 mm. (2 to 3 inches). They are nocturnal, and are attracted to lights. Two species have been described. *P. punctātus* is our most common one; it is blackish, with three longitudinal lines on the disk of the prothorax, and the lateral margins of this segment yellowish. *P. vittātus* is pale yellowish, with a black stripe on the sides of the thorax, and with the abdomen dark brown. The larva of neither of these species is known. They are probably aquatic.

Micrōmus includes smallish species having an alar expanse of from 10 to 20 mm. (0.4 to 0.8 inch). My personal experience leads me to believe that they are rare; and I find no published accounts of the appearance and habits of the larvæ.

Hemerōbius is much better known; although the species of this genus are not common. More than twenty North American species have been described. These are also smallish insects ranging in alar expanse from 8 to 20 mm. (0.3 to 0.8 inch). They occur in forests, and especially on Coniferous trees. The larvæ bear a strong resemblance to the Aphis-lions; and like them feed upon Aphids and other small insects. After sucking the fluids from their victims, they make a cloak for themselves of the empty skins.

Sub-family III.—CHRYSOPINÆ.

(*Lace-winged Flies or Aphis-lions.*)

Nearly all of the species of this sub-family pertain to the genus *Chrysōpa*. These insects are known in the adult state as Lace-winged

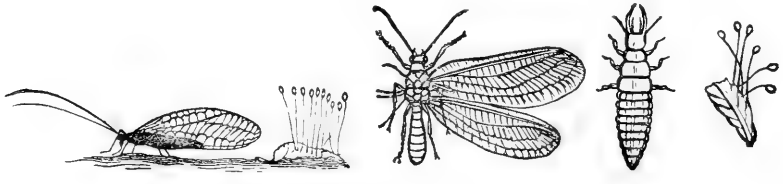


FIG. 192.—*Chrysopa*, eggs on stalks, larva, and adult.

Flies, and in the larval form as Aphis-lions. The antennæ of the adult are long and setaceous; the venation of the wings resembles somewhat that of the preceding sub-family; but the subcostal and

median veins are separate, and the transverse veins of the costal space are not forked.

The lace-winged Flies are very common insects throughout the summer months upon herbage and the foliage of trees. They are usually of a light green color or yellowish. While alive their eyes are very bright; and on this account they have also received the popular name of Golden-eyed Flies. Some species, when handled, emit a very disagreeable odor. A remarkable fact in the history of these insects is the way in which the female cares for her eggs. When about to lay an egg she emits from the end of her body a minute drop of a tenacious substance; this is drawn out into a slender thread by lifting the abdomen: then an egg is placed on the summit of this thread. The thread dries at once and firmly holds the egg in mid-air. These threads are usually 10 to 15 mm. (0.4 to 0.6 inch) in length, and occur singly or in groups. It is probable that this placing of the eggs on stalks protects them from the ravages of predaceous insects, including the aphis-lions themselves. When the young aphis-lion hatches it crawls down the thread that held up the egg, and starts in quest of some small insect or egg which it can feed upon. While doing so it may wander through a forest of egg-stalks, not observing the eggs far above it. The larvæ are spindle-form, and have long, sickle-shaped mandibles. They feed chiefly on plant-lice, but will eat such other insects as they can overcome. The cocoon in which the pupa state is passed is spherical, and composed of dense layers of silk. In order to emerge the insect cuts a circular lid from one side of the cocoon.

Sub-family IV.—Myrmeleoninæ.

(*Ant-lions et al.*)

The members of this sub-family can be distinguished from other Hemerobiadæ by the form of the antennæ. Two types of antennæ exist in the sub-family, but in each the organs are enlarged at or near the tip; while in other Hemerobiadæ the antennæ are without a terminal enlargement.

The genera of this sub-family constitute two groups, each of which is represented in our fauna by a well-known genus. These two genera include nearly all of our species. The first group is represented by *Myrmēlcon*. Here the antennæ are short and gradually thickened towards the tip. In the second group, represented

by *Ascălaphus*, the antennæ are long, filiform, and suddenly enlarged at the end.

The Ant-lions, *Myrmēleon*.—This is a large genus; Hagen, in his Synopsis published in 1861, describes twenty-five American species. The adult insects are graceful creatures, with long, narrow, delicate wings and slender bodies. The larvæ have broad and somewhat depressed bodies which taper towards each end. The form of the mouth-parts has been described in the generalizations regarding the Hemerobiadæ. The interesting habits of these larvæ have attracted much attention since the earliest times. They live in sandy places, where they dig pitfalls for trapping their prey. In making these pitfalls the sand is thrown out by an upward jerk of the head, this part of the body serving as a shovel. The pits differ greatly in depth, according to the nature of the soil in which they are made. Their sides are as steep as the sand will lie. When an ant, or other wingless insect, steps upon the brink of one of these pits, the sand crumbles beneath its feet, and it is precipitated into the jaws of the ant-lion, which is buried in the sand, with its jaws at

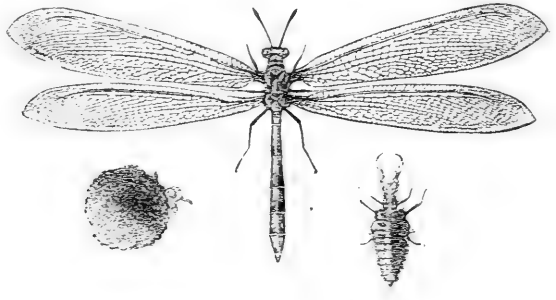


FIG. 193.—*Myrmeleon*.

the bottom of the pit. In case the ant does not fall to the bottom of the pit, the ant-lion undermines it by throwing out some sand from beneath it. I have even seen an ant-lion throw the sand in such a way that in falling it would hit the ant and tend to knock it down the side of the pit. These larvæ can be easily kept in a dish of sand, and their habits watched. The pupa state is passed in a spherical cocoon, made of sand fastened together with silk, and neatly lined with the same material. This silk is spun from a spinneret, placed at the caudal end of the body, the caudal part of the alimentary canal being transformed into a silk gland. The food of

these larvæ is of such a nature that it can all be absorbed, and thus the rectum is not needed for the passage of waste matter.

Ascălaphus.—As already stated, this genus differs from the ant-lions in the form of its antennæ. The body is short, and the wings are less densely veined than in *Myrmeleon*. The early stages of our species have not been observed. In case of certain European species the eggs are laid upon the stems of grass; and the larvæ live upon the ground, hiding under stones, and seizing, by stepping forward, insects that pass near them.

Sub-family V.—MANTISPINÆ.

(*The Mantis-like Neuroptera.*)

This remarkable sub-family is represented in our fauna by a single genus, *Mantispa*. These insects present an unusual form of the prothorax and the first pair of legs; a form that strikingly resembles the shape of these parts in the family Mantidæ of the order Orthoptera. The prothorax is elongated, cylindrical, and more or less trumpet-shaped. The first pair of legs are enlarged and fitted for grasping. The wings are narrow, the two pairs similar; and the costal and subcostal veins are confluent near the middle of the costal margin.

As indicated by the form of the grasping legs, the adult *Mantispa* resembles the true *Măntis* in its predaceous habits. The transformations of these insects are of unusual interest. It was accidentally discovered that the larvæ were parasitic in the egg-sacs of spiders of the genus *Lycosa*. These are the large black spiders that are common under stones, and which carry their egg-sacs with them. Brauer obtained eggs from a female *Mantispa* kept in confinement. These eggs were rose-red in color, and fastened upon stalks, like the eggs of *Chrysopa*. The eggs were laid in July; and the larvæ emerged 21 days later. The young larvæ are very agile creatures, with a long, slender body, well-developed legs, and long, slender antennæ. They pass the winter without food. In the spring they find their way into the egg-sacs of the above-named spiders. Here they feed upon the young spiders; and the body becomes proportionately thicker. Later the larva moults and undergoes a remarkable change in form, becoming what is known as the second larva. In this stage the body is much swollen, resembling in form the larva of a bee. The legs are much reduced in size; the antennæ are short; and the head is very small. When

fully grown this larva measures from 7 to 10 mm. (0.3 to 0.4 in.) in length. It then spins a cocoon, and changes to a pupa within the skin of the larva. Later the larval skin is cast; and, finally, after being in the cocoon about a month, the pupa becomes active, pierces the cocoon and the egg-sac, crawls about for a time, and then changes to the adult state.

Family III.—Panorpidæ.*

Order Mecoptera † of some authors.

(*Boreus, Scorpion-flies, et al.*)

This is a small family; but it is composed of very remarkable insects. The most striking character common to all is presented by the mouth. This is prolonged into a rostrum, as shown in the figure. The body is cylindrical or conical; the head is exserted; the prothorax is small; and the tarsi are five-jointed. So far as is known the members of this family are carnivorous. There are only four described genera. These can be separated by the following table:

Fig. 194.—Head and tail of *Panorpa*.

A. Wingless or with rudimentary wings.	Boreus.
AA. With well-developed wings.	
B. Wings narrow; antennæ setaceous.	
C. Tarsi with two serrated claws.	Panorpa.
CC. Tarsi with a single simple claw.	Bittacus.
BB. Wings broad; antennæ short, thick, the apex narrowed.	Merope.

Bōreus.—Among the few insects that occur on the snow, in the winter, in our Northern States, are two species of the genus *Boreus*. In this genus the wings of the female are very rudimentary; those of the males are about half as long as the abdomen, narrow, stiff, and entirely useless for flight. *Bōreus nivoriŭndus*, the Snow-born Boreus, is shining black or brownish black, with the rudimentary wings, thorax above, and the rostrum and ovipositor excepting their tips, tawny. The male measures 3 mm. (0.12 in.) in length; the female, including the ovipositor, $4\frac{1}{2}$ mm. (0.16 in.). The Midwinter Boreus, *B. brumālis*, is smaller; the male measuring $2\frac{1}{2}$ mm. (0.1 in.), and the female 3 mm. (0.12 in.), in length. This species is deep black-

* Panŏrpidæ, Panorpa: *pan* (πάν), all; *horpe* = *harpe* (αρπη), a sickle.

† Mecŏptera, incorrectly written *Mecaptera: mecos* (μῆκος), length; *pteron* (πτερόν), wing.

green; with the legs, antennæ, rostrum, and ovipositor black, and the rudimentary wings brownish black. Both species are found on the snow throughout the entire winter. They also occur in moss on tree-trunks. It is not known whether they feed on the moss or upon Thysanurians and other small insects which they find there. These insects have long legs, and are able to leap to a limited extent. The females are furnished with a long, curved ovipositor, resembling that of a cricket. The early stages of our species have not been studied. The larva of a European species has been found throughout the summer in the ground and upon stones under Liverworts.

The Scorpion-flies, *Panŏrpa*.—These are our most common representatives of the family. They are called scorpion-flies on account of the peculiar form of the caudal part of the abdomen of the male. This at first sight suggests the corresponding part of a scorpion; but in reality the form is very different. The last segment, instead of ending in a sting like that of a scorpion, is greatly enlarged, and bears a pair of clasping organs. The wings are narrow, but are well developed, being longer than the body. In our more common species they are yellowish spotted with brownish black. The early stages of several European species have been studied. The eggs are laid in a mass in a shallow hole, which the female bores with her abdomen in damp earth. The larvæ are remarkable on account of their great resemblance to caterpillars.* Not only is the form of the body like that of Lepidopterous larvæ, but the abdomen is furnished with fleshy prop-legs. There are, however, eight pairs of these; while caterpillars never have more than five pairs. The larvæ which were kept in confinement were fed raw beef; they made horseshoe-shaped mines in the earth, one end of which opened beneath the meat. Their natural food is unknown.

FIG. 195.—*Panorpa*, adult.

Bittacus.—The insects of this genus resemble the scorpion-flies in having long, narrow wings, three ocelli, and very slender, setaceous antennæ. But the caudal appendages of the male are not enlarged as in Panorpa. The legs of *Bittacus* are very long; this with the narrow wings and slender abdomen cause these insects to resemble Crane-flies. They are predaceous, the European species

* The larvæ of three species are figured by Brauer, Verhandl. der k. k. zool. bot. Gesellsch., Band XIII. taf. 13.

having been observed to capture and destroy flies. Brauer figures the larva of one species, and represents it with six true legs and eight pairs of conical prop-legs. Unlike the larvæ of *Panorpa*, this did not mine in the ground, but remained on the surface hiding under dry leaves and other rubbish.

Mĕrope.—This genus was established for a very rare and remarkable species. The wings are broad, with many transverse veins; the ocelli are absent; the eyes are large, kidney-shaped, and united at the vertex; the antennæ are short, thick, and with the apex narrowed. The abdomen of the male has very large forceps.

Family IV.—Phryganeidæ.*

Order Trichoptera of some authors.†

(*Caddice-flies.*)

The Caddice-flies are moth-like insects, which are common in the vicinity of streams, ponds, and lakes; and they are also frequently attracted to lights at night. But the larvæ of these insects are much better known than the adults; for the curious houses of the caddice-worms have attracted attention wherever there are observers of insects.

Fig. 196.—Caddice-fly.

In the adult insect the body-wall is soft, being membranous or at the most parchment-like, and is thickly clothed with hairs. There are usually four ample wings. These are membranous; but the anterior pair are more leathery than the posterior. When not in use they are folded against the sides of the abdomen, in an almost vertical position, and give the insect a narrow and elongated appearance. The wings are more or less densely clothed with hairs. In some cases the hairs are scale-like in form. The second pair of wings are generally broader than the front wings, and are often longitudinally folded in repose. All have numerous longitudinal veins; but the transverse ones are few.

The head is small; the antennæ are sectaceous, and frequently several times as long as the body; the labium is usually elongate; the mandibles are mere tubercles at the base of the labium; the maxillæ are small, and ordinarily furnished with an obtuse maxillary

* Phryganēidæ, Phryganēa: *phryganon* (φρύγανον), a dry twig.

† Trichŏptera: *thrix* (θρίξ), a hair; *pteron* (πτερόν), a wing.

lobe; the maxillary palpi are well developed, and furnish characters which are much used in classification; the labium is usually well developed, and bears three-jointed palpi.

The females deposit their eggs in masses enveloped in a gelatinous covering. These are often found adhering to the end of the body in captured specimens. It is supposed that these eggs are usually deposited on aquatic plants; but it is known that in some cases the females descend below the surface of the water to oviposit.

The larvæ are long, cylindrical, soft-bodied, and furnished with six well-developed thoracic legs and a pair of anal legs. The abdomen bears a greater or less number of hair-like tracheal gills. These larvæ protect themselves by building a case about the body, in which they live during the larval and pupal stages. These cases vary greatly in form, and in the materials used in their construction; but in general those made by the larvæ of any given species are very similar.

'One of the most interesting topics which a young entomologist can take for study is the habits of these insects. The larvæ can be easily found throughout our country. Many species can be kept in aquaria; but others, those that live in swiftly-flowing water, must be observed in their native haunts. I will indicate a few of the general features in the economy of these insects. The facts given here can be easily supplemented by any careful observer.

Among the simplest of the various forms of houses built by caddice-worms are those made by certain species that live under stones in rapid streams. These consist merely of a few pebbles fastened to the lower surface of a larger stone by threads of silk. In the space between these stones the worm makes a more or less perfect tube of silk, within which it lives. Very little respect for the architectural skill of these builders is commanded by their rude dwellings. But if one looks a little farther, something will be found that is sure to excite admiration. The dweller within this rude retreat is a fisherman; and stretched between two stones near by can be seen his net. This is made of threads of silk extending in two directions at right angles to each other, so as to form meshes of surprising regularity. It is as if a spider had stretched a small web in the water where the current is the swiftest. In the streams about Ithaca these caddice-worm nets are very abundant. They occur in the rapids between stones, but are to be found in greater numbers along the brink of the falls. Here they are built upon the surface of the rock, in the form of semi-elliptical cups, which are kept dis-

tended by the current. Much of the coating of dirt with which these rocks are clothed in summer is due to its being caught in these nets. I have not yet observed the owners of the nets taking their prey from them; but I cannot doubt that they are made to trap small insects or other animals that are being carried down stream, for the larvæ of the sub-family to which these net-builders belong, the *Hydropsychinæ*, are known to be carnivorous. It should be noted here, however, that the greater number of caddice-worms are herbivorous.

There are many caddice-worms that build their cases of stones; some of these cases are very regular in form. One of the common kinds resembles a slightly tapering cornucopia, made of small grains of sand, cemented together with great regularity. Another consists of a shorter tube, to each side of which are fastened one or two larger stones, as if to keep it in position (Fig. 197). But more re-

FIGS. 197, 198.—Cases of Caddice-worms.

markable than either of these is the case (Fig. 198) which so closely resembles in form the shell of a snail that it has been described as such by several conchologists.

We find among the caddice-worms carpenters as well as masons. And there exists among the builders of wood as great a variety of architectural tastes as among the builders of stone. Probably the most familiar of the forms of cases made of wood is that represented in Fig. 199. This is made of irregular pieces of wood arranged in a

FIGS. 199, 200.—Cases of Caddice-worms.

longitudinal manner. Much more likely to attract attention is the case composed of sticks placed at right angles to the body (Fig. 200).

These remind one of the cob-houses of our childhood. Fortunately the species that make this style of case live in stagnant water, and may, therefore, be kept alive in aquaria. A case closely resembling this in plan but differing in appearance is made of bits of moss. Sometimes leaves are used; these are either fastened so as to form a flat case; or are arranged in three planes, so as to form a tube, a cross section of which is a triangle.

Whether stones or wood are used, the material is fastened together by silk, which the larvæ spin from the mouth in the same manner as caterpillars. In some species the case is composed en-

FIG. 201.—Case of Caddice-worm.

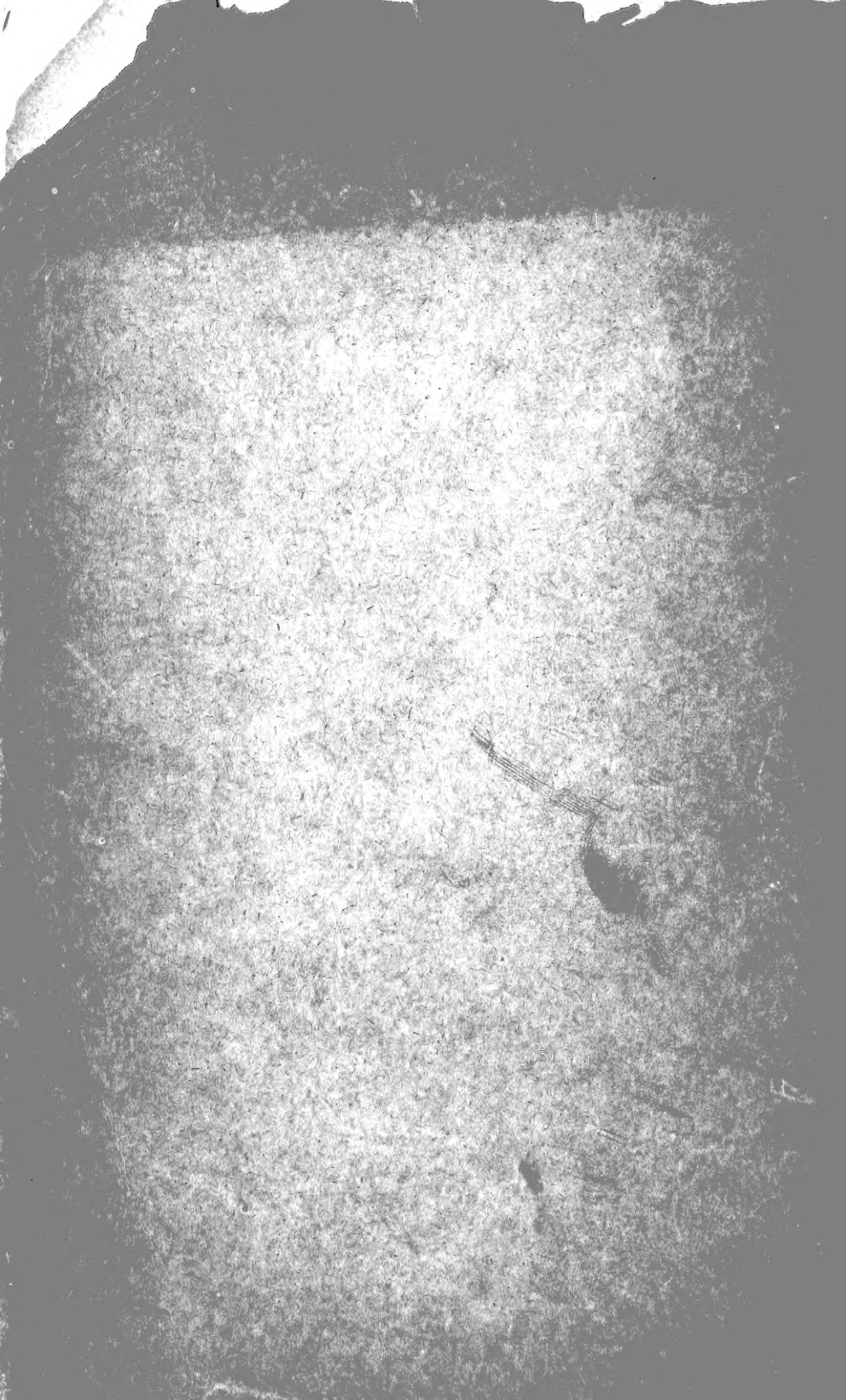
tirely of silk. Fig. 201 represents the form of such a case, which is common in Cayuga Lake.

Before transforming to pupæ, the caddice-worms partially close their cases, so as to keep out intruders; but provision is made for the ingress of water for respiration. Thus the owner of the silken case to which reference has just been made, when ready to transform, fastens its case to a stem of the grass which grows in the lake, and then closes the entrance to the case with a lid having a slit-like opening in the centre. The worms making the cases shown in Fig. 199 build a grating in each end of the case.

It would naturally be supposed that the caddice-worms would escape the attacks of Ichneumon-flies, living as they do beneath water, and within well-built tubes. But this is not so. And curiously enough, in certain species at least, the parasitized individuals differ from others in fastening their cases by means of a long band, when about to transform, instead of attaching them directly to the supporting object.

In the Phryganeidæ we find another group which differs in such important characters from the most nearly allied insects that many entomologists believe it should be classed as a distinct order; and long ago the name Trichoptera was proposed for this order. The rudimentary mouth-parts of the adult caddice-flies and the structure of the wings separate them from the other Neuroptera, and suggest affinities with the Lepidoptera; on the other hand, the anal legs of the larvæ with hooked claws resemble those of the Sialidæ. As indicating the strength of the tendency to recognize the order Trichoptera, it is only necessary to name Hagen, McLachlan, and Brauer as among those that share this view.

The American species of the Phryganeidæ have not been monographed. One hundred and fifty species are described in Hagen's Synopsis of the North American Neuroptera; comparatively little has been written regarding the American forms during the quarter-century that has elapsed since the appearance of that work. The student who wishes to make a special study of this group should possess the great work of Robert McLachlan, *A Monographic Revision and Synopsis of the Trichoptera of the European Fauna*. There is also a paper by Friedrich Brauer which is very useful. This is entitled *Verzeichniss der bis jetzt bekannten Neuroptera im Sinne Linne's*, and is published in the *Verhandlungen der Zoologisch-Botanischen Gesellschaft, XVIII.* (1868). It contains analytical keys to the sub-families, and to all of the genera described at that time.



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